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SCIENCE

9 September 1960
Vol. 132, No. 3428

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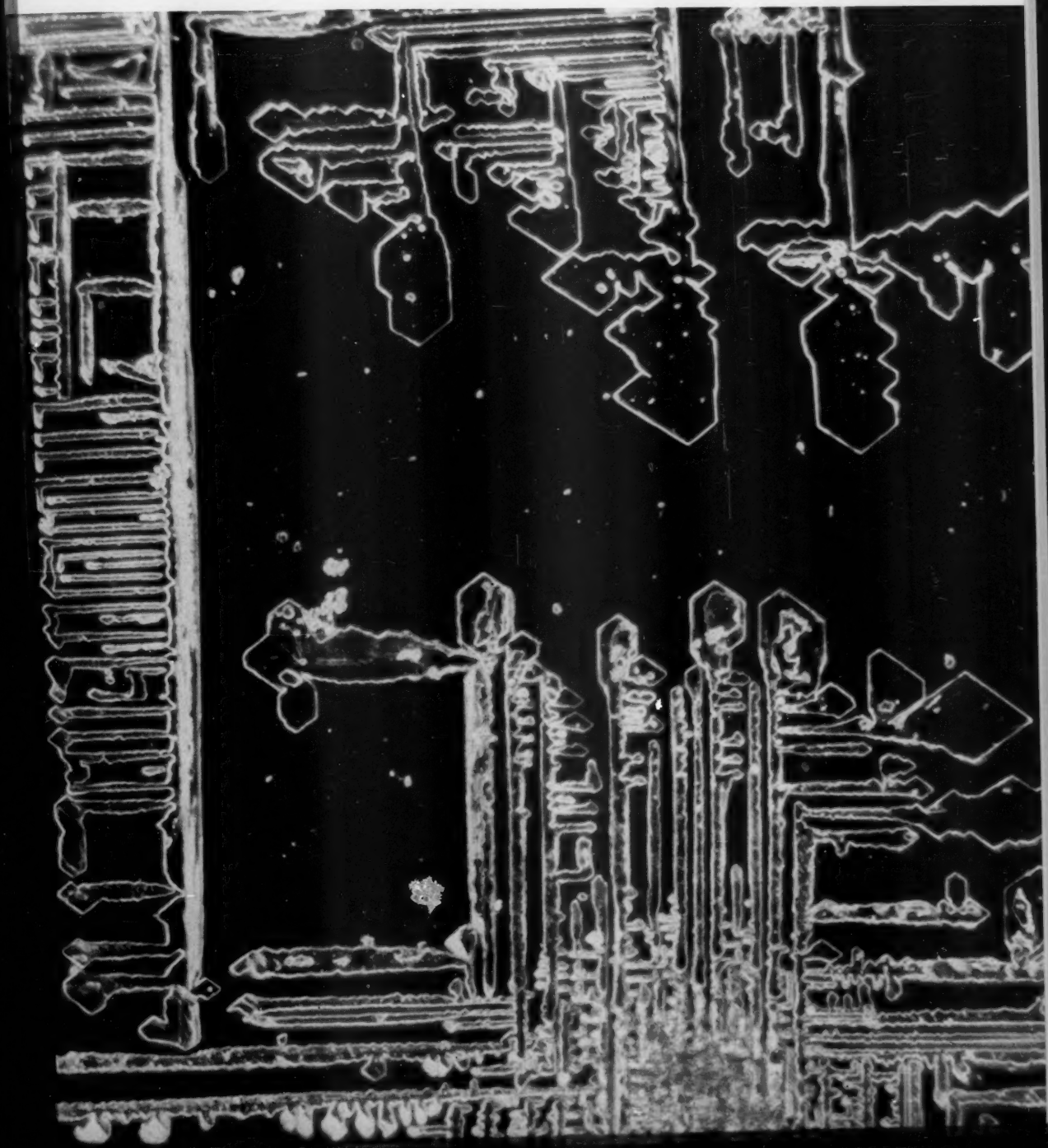

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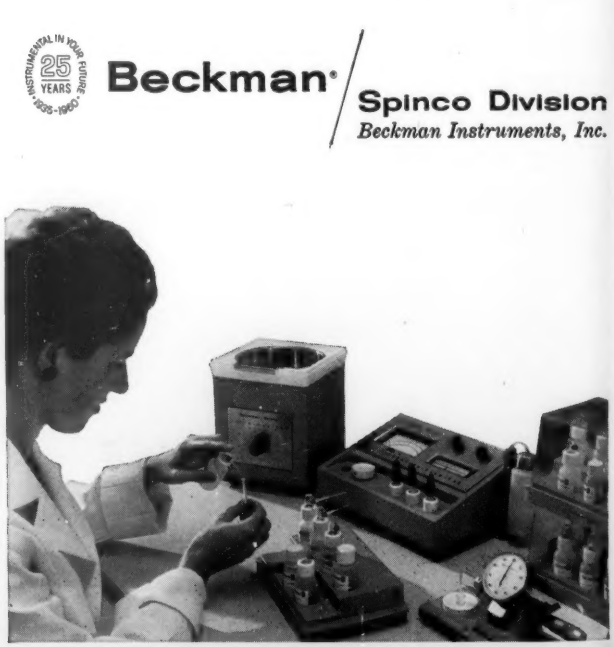

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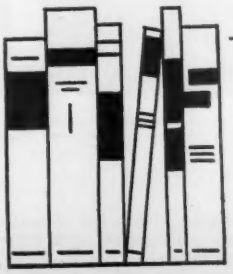

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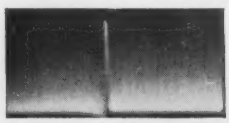
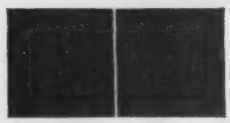
A human talent

The June issue of *Scientific American* contained an article full of learned speculation on the neurological mechanism by which lines, straight and curved, are perceived. Whatever the mechanism, the fact remains that the nervous system is very good at seeing a line from exceedingly faint physical stimuli. We had been thinking about this a lot and about ways it could help solve the nasty signal-to-noise problem that keeps cropping up on such occasions as when defense from submarine attack is considered. Today's almost instantly available photographic images make a fine bridge from an electronic system to a human nervous system. For example:

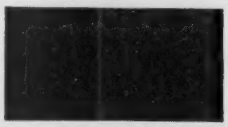


1. Instead of an ordinary A-scope trace like this . . .



let's modulate intensity and sweep over moving film with much overlap . . .

2. so that even when the significant pulse stands out from the noise no more than this . . .



photographic summing-up finds it rather easily;

3. and even when the A-scope shows only this . . .

the weak but non-random blip holds position and builds up from all the sweeps to where the marvelous combination of photography and the human perceptive mechanism says, "There!"

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For a list of the headquarters of each participating society and section, see page 230, *Science*, 22 July. Both the Commodore and the Biltmore are AAAS headquarters hotels.

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EXAMPLE

Determination of the Spin-Lattice Relaxation Time (T_1) of F Centers in KCl

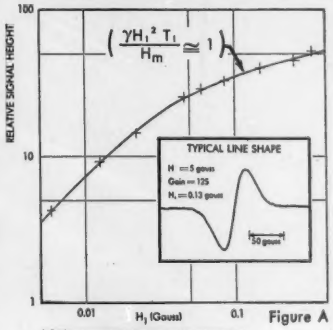
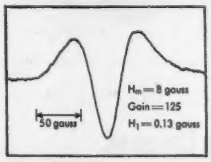
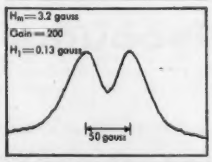


Figure A





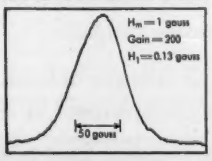


Figure B

Structure defects involving unpaired electrons in crystalline solids generally exhibit a resonance response characteristic of spins immersed in a continuous distribution of magnetic fields. Each electron spin interacts with many neighboring nuclei. The orientation of the nuclear magnetic moments with or against the electron spin, together with the strength of the interactions, determines the local magnetic field, which will be different for every electron. The F center in an alkali halide (an electron occupying a vacant halogen ion site) is a prototype of such a system. In KCl the electron interacts with its nearest neighbor, potassium nuclei, as well as with more distant nuclei to give a line of Gaussian shape of 50 gauss width with no observable structure.

In such a system, with about 10^{17} centers per cc, dipole-dipole interaction is weak and the corresponding relaxation time, T_2, is replaced with T_1 in theoretical treatments. Portis investigated the saturation response of this system* and determined T_1 at room temperature using a spectrometer employing amplitude modulation of the klystron output. He found that the observed EPR absorption signal $\chi''H_1$ became independent of the microwave field amplitude, H_1, at saturation, and found a value for T_1 of 8 x 10^{-6} sec. at room temperature.

We were interested in studying the saturation behavior of this system with the Varian EPR spectrometer employing field modulation at a frequency $\omega_m = 2\pi \times 10^6$. If $\omega_m T_1$ is greater than 1, the modulation amplitude, H_m, appears in the saturation parameter. Saturation was expected to occur when $\frac{\gamma H_1^2 T_1}{H_m} \cong 1$. Figure A shows an experimental saturation curve, in which the amplitude of the absorption $\chi'' H_1$, is plotted vs H_1. It is possible to produce a theory to account for the observed behavior, but the break at saturation is not sharp and at best many measurements are required to determine T_1.

One may obtain a value of T_1 much more quickly by observing the dispersion (χ'). Upon saturation, the line shape passes from the typical derivative of the dispersion to the rapid passage shape observed in inhomogeneous systems.** This line shape is the actual distribution of spins in the local magnetic fields. It arises from a summation of the rapid passage responses of the spin packets which compose the line as the modulation field sweeps back and forth sinusoidally. One may vary either H_1 or H_m to bring about saturation; Figure B shows three curves obtained by varying only the modulation amplitude H_m. They illustrate intermediate cases as one is passing into the saturation region. If one solves for T_1 for those values of H_m and H_1 which produce the central curve shown, one obtains a value of 1 x 10^{-6} sec., which is in good agreement with the value obtained by Portis.

A. M. Portis, Phys. Rev. 91, 1071 (1953), Phys. Rev. 104, 584 (1956).
**J. S. Hyde, Phys. Rev. (to be published).*

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What We Know and Don't Know

An embarrassing proportion of key decisions in the government, from the negotiation of treaties to the management of resources, are made on the basis of insufficient information and unproved assumptions. And this is not so different from the way we conduct our private affairs. We do not know what lies beyond the horizon, and science can only map the boundaries of our ignorance. But since science is in part responsible for some of the greatest ills that now beset us, there is a feeling that it can also help us effect their cure. The government has been acquiring scientific advisory bodies, and the belief that the public is entitled to its own counsel from an independent source is gaining adherents. One move to provide such counsel is to be found in the proposals offered recently by the AAAS Committee on Science in the Promotion of Human Welfare.

In the 8 July issue of this journal the committee speaks of bringing together appropriate technical experts to discuss certain problems, and of reporting the results of such deliberations to the scientific community. The results would also be reported to the general public, in a form not only digestible but palatable. The range of topics is broadly conceived, but some of the reports would analyze the benefits and hazards of scientific and technological advances and thus provide a basis for intelligent appraisal by scientist and layman. The committee does not explore in detail suitable problems for such analyses, but it does offer a few examples of what it has in mind. These range from the more specific, such as methods to prevent air pollution resulting from car exhaust, to the more general, such as the implications of the "new capabilities for direct control of social and economic processes" resulting from "progress in the science of cybernetics and the development of automation techniques."

An article on radioactive fallout which appeared early this year in the New York *Times* magazine was given the subtitle "What We Know and Don't Know." And perhaps reports analyzing the social effects of scientific developments might also appropriately be so subtitled. The relative proportion of material in the two categories would differ for different problems. For one problem, much might be known, and the needed research, once public interest was alerted to dangers, might consist only in finding the most economical method for manufacturing some device. For another problem, so little might be known that it would be difficult to state just how investigators would go about finding a scientific basis for possible public action.

The success of the projected program of analyses will depend in part on the care with which the first problems for study are selected. It goes without saying that a problem chosen for study should concern a matter of some urgency. But in the early stages of a new program, when there are no models to follow and it is important to gain widespread support, there is another factor to consider. A report with a solid amount of information to convey is going to be less difficult to prepare, and is going to impress the scientific community and the general public more favorably, than a report that must, out of ignorance, be an extended plea for more research.—J.T.

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CURRENT PROBLEMS IN RESEARCH

Ultrasonic Absorption in Solids

How high-frequency sound is damped by imperfections in solids.

Thomas S. Hutchison

The main interest of the ancients in the absorption of sound was an indirect one. It concerned the fabrication of bells, which, until about the 8th century, were made of beaten iron sheets riveted together. About then, the practice of casting of bells, or "bell founding," began. For the latter, the preferred composition of "bell metal" became, by the 16th century, copper and tin in the ratio of about three to one. Both the practice of working the iron sheets by beating and that of alloying, in the case of "bell metal," reduce the movement of imperfections in the metal, and this, as will become clear from the discussion, gives rise to a decrease in the attenuation of acoustic waves, so giving clear and prolonged ringing.

It is, however, only during the present century that most of the real mechanisms of acoustic damping have become known. The elucidation of the nature of these mechanisms had to await a clearer picture of the actual atomic nature of solids (*1*).

The techniques of modern physics have produced this revelation. Solids are now known to be mostly crystalline; this means that the atoms of which they are built are arranged in space in a regular pattern, the planes of a similar nature being parallel over the whole volume of the crystal. Such single crystals can now be grown in many instances to a volume of several cubic inches.

The use of x-ray diffraction techniques has made it possible to measure the exact positions of the atoms in the crystal lattice. Electron diffraction has given insight into the nature of the surfaces of solids, and, more recently, neutron diffraction, with radiations much more penetrating than either x-rays or electrons and with characteristics of scattering by atoms different from either, has revealed the positions of certain atoms which are invisible to x-rays.

Optical microscopy, complemented by the use of polarized light, is now a standard technique of the metallurgy laboratory for the examination of prepared solid surfaces. The wealth of experience that has been accumulated now enables the technologist to deduce the bulk nature of the solid element or alloy from the evidence of the surface.

Lattice Imperfections

Of more recent interest is the examination of the nature of the lattice imperfections which occur in natural and fabricated solids. The examination of solids by ultrasound is of importance primarily in the elucidation of the nature of the imperfections rather than in elucidation of the nature of the perfect crystalline lattice.

Let us then deal with some of the different kinds of imperfections which are always found in solids, even in solids produced under the most careful growth conditions.

First of all, the solid element is not pure. Foreign atoms occur in two kinds of position in the lattice. They may take the place of one of the solvent atoms in the substitutional kind of alloy or be squeezed in between the atoms of the element in interstitial positions. It is found that the main factor governing the choice of kind of alloy is one of size of the foreign atom relative to size of the matrix atom. If the atoms of solute and solvent are within about 15 percent of each other in size, then the alloy is likely to be substitutional, whereas interstitial atoms are generally much smaller than solvent atoms and can as a consequence be accommodated in the interstices of the geometrical atomic structure. The presence of quite small numbers of foreign atoms markedly affects many of the physical characteristics of the solid. This is not surprising, since it may be easily calculated that in an alloy with, say, one foreign atom per thousand lattice atoms, few points in the alloy, if it is homogeneous, are more distant from a foreign atom than about eight atomic spacings.

At temperatures above absolute zero the equilibrium configuration of the atoms in the lattice is such that point defects, such as atoms out of their normal positions, must exist. The configurational entropy S of the lattice containing such defects contributes to a lowering of the free energy F in the expression $F = U - TS$, where T, the temperature, is not zero. The condition of minimum free energy is in all such systems that of greatest likelihood in equilibrium.

The two kinds of single point defect commonly encountered are the Schottky type and the Frenkel type; in the Schottky type the atom out of position is located at the surface while in the Frenkel type the misplaced atom is in

The author is professor of physics and head of the department at the Royal Military College of Canada, Kingston, Ontario.

an interstitial position. It is common for such point defects to exist in clusters. Such defects may interchange positions with atoms of the lattice or with foreign atoms, interchanges that give rise to self-diffusion or to impurity diffusion. In ionic solids these defects are charged and their movement constitutes an electrical current, the conductance being strongly dependent on temperature, as are all diffusion processes.

In addition to point defects, investigation of the plastic properties of solids has revealed different kinds of line defects or "dislocations." Figure 1 shows

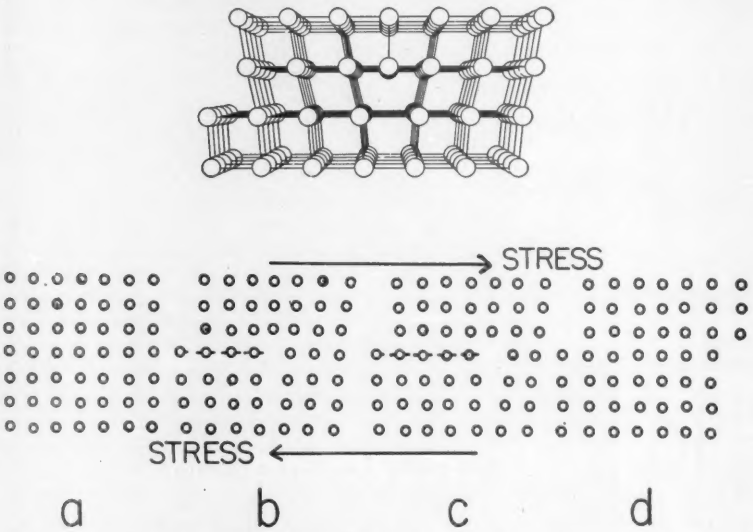

Fig. 1. The upper figure shows a positive edge dislocation. The lower sequence *a*, *b*, *c*, *d* shows how such a dislocation, once generated, may move to the right under a shearing stress; *b* corresponds to the upper figure while *d* shows the resulting slip displacement when the dislocation has moved right across the slip plane.

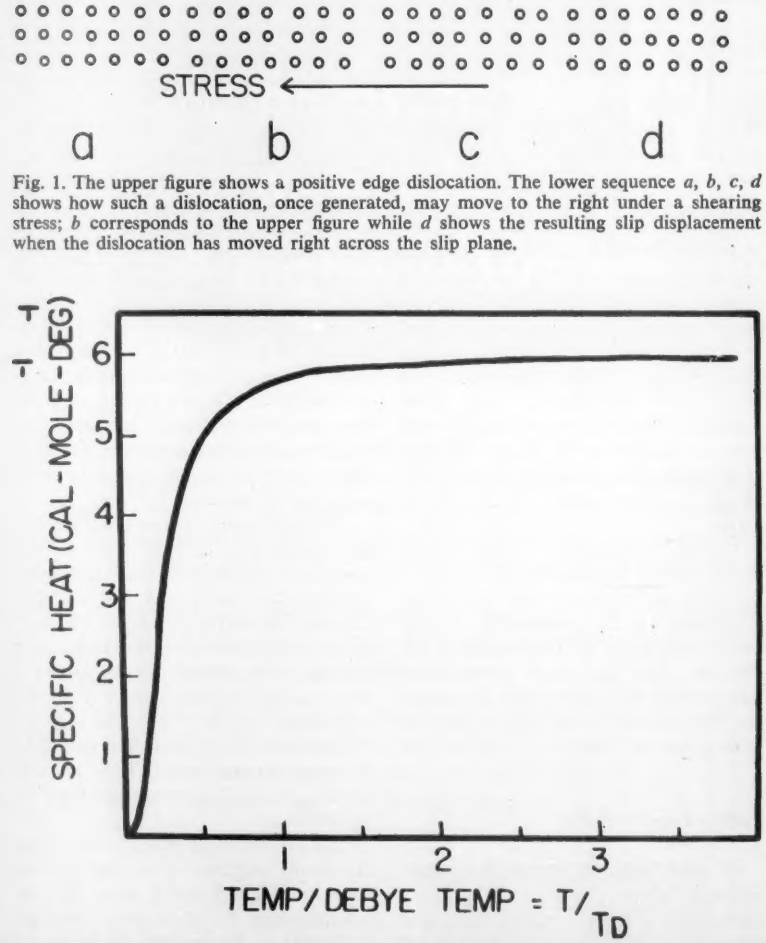

Fig. 2. Specific heat of a solid as a function of temperature. The temperatures are quoted as ratios T/T_D where $kT_D = h\nu_{max}$ (see text).

the simplest of these dislocations and the manner in which it can move through the solid. A theoretical calculation of the applied shear stress that will cause two planes of atoms in a crystal to slip relative to each other gives a value which is of the order of 1000 times greater than the highest experimentally observed yield stress. Taylor (*2*), Orowan (*3*), and Polanyi (*4*) first suggested that the mechanism of slip takes place through the movement of dislocations across a slip plane and were able by this means to account for the small value of the observed shear strength. This idea has been immensely fruitful in the explanation of a great number of mechanical properties of solids. Recently the work of Hirsch (*5*) and his co-workers at Cambridge has revealed by electron optics the very existence of dislocations.

Dislocations occur as a network throughout the crystal, being anchored at the crossing points. Point defects and impurities may also pin down the dislocation loops at intermediate points. The number of dislocations through each square centimeter of solid crystal is generally of the order of 10^5 to 10^9 and may be increased in metals to about 10^{12} by plastic deformation.

The lattice of atoms in a solid is in continuous vibration due to thermal energy. The particle aspects of the normal modes of vibration are called "phonons" and also constitute imperfections in the crystalline solid. The energy E of a phonon is given by the relation $E = h\nu$, where ν is the frequency of the lattice vibration considered and h is Planck's constant ($= 6.62 \times 10^{-34}$ joule-sec). The vibrations form a spectrum varying from low frequencies up into the infrared region. Figure 2 shows the specific heat for a crystal at different temperatures where the temperatures are quoted as a fraction of the Debye temperature T_D which is defined by $kT_D = h\nu_{max}$, where k is the Boltzmann constant ($=1.38 \times 10^{-23}$ joule/°K) and ν_{max} is the highest frequency of phonon vibration in the lattice. From the graph it can be seen that at temperatures above T_D the specific heat, which is a measure of the amount of energy which must be added to raise the temperature by a specific amount, is almost constant, indicating that all the modes of vibration are excited, while at low temperatures the specific heat drops off because thermal agitation is not strong enough to excite the high energy vibrations of the crystal.

The interaction of electrons, phonons, and defects establishes thermal equilibrium in the lattice, while scattering by phonons and defects of the charge carriers—electrons and "holes"—endows the solid crystal with electrical resistivity. The flow of heat in good conductors such as metals is mostly by the passage of electrons, and in poor conductors, by the diffusion of phonons. This phonon diffusion does not proceed at the velocity of sound as it might be expected to do since thermal vibrations are merely extremely high frequency acoustic waves, but at much slower speeds because of scattering. The main cause of phonon-phonon scattering is due to what is called the anharmonicity of the forces in the crystal—that is, the nonlinearity of the restoring force on an atom as a function of its displacement from its equilibrium position. This means that the reaction of the lattice to a phonon will depend on whether another phonon is also passing through at the same time.

The remaining type of imperfection concerned with acoustic attenuation is the free electron. The free electron represents a singularity in the crystalline electric field which may perceptibly distort the lattice in the vicinity. Free electrons were originally represented as particles in the Drude-Lorentz theory, which, although now replaced by a quantum mechanical picture, is still useful in giving a more easily envisaged model of conduction. Electrons interact with phonons, impurities, and lattice defects, so that at room temperature the electron "mean free path" or distance between collisions is of the order of 10^{-6} centimeter, while at low temperatures this increases by a factor of 10^3 to 10^4.

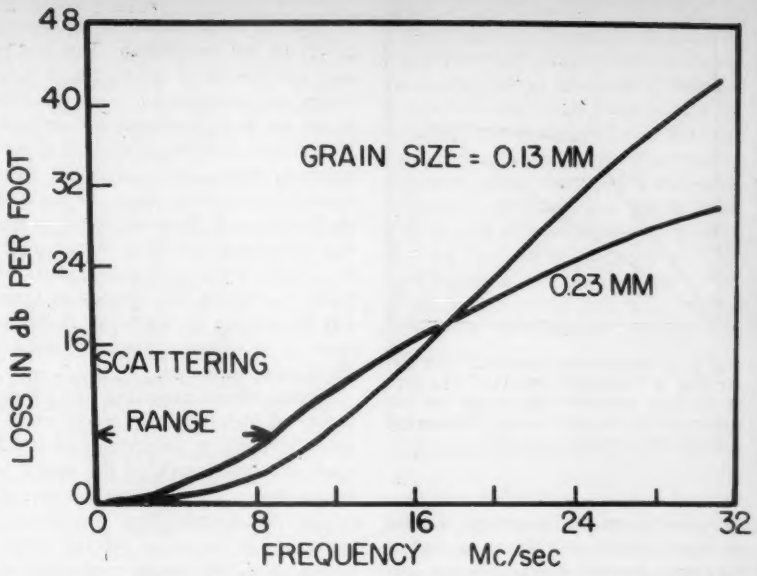

Fig. 3. Attenuation of high-frequency sound by scattering in two aluminum rods of different grain sizes. The larger grained material, being closer in grain size to the acoustic wavelength at the lower frequencies, gives the greater Rayleigh scatter. When the wavelength becomes shorter than the grain size, the attenuation becomes independent of frequency.

Measurement of Attenuation

Before we consider the mechanisms by which these defects contribute to a loss of acoustic energy in a solid, let us discuss the quantities which are used to provide a measure of the attenuation.

When a solid is set in mechanical vibration, some of the elastic energy is always converted into heat, the mechanisms by which this takes place being collectively called "internal friction." Thus, when a solid specimen vibrates, its free oscillations decay even when it is isolated from its environment.

The most direct way of defining internal friction is as the ratio of the energy dissipated in taking the specimen through a stress cycle to the elastic energy stored in the specimen when the strain is a maximum. This ratio, $\Delta W/W$, is called the "specific loss." The value of specific loss is often found to depend on the amplitude and frequency of the applied stress and is always modified by the temperature and past history of the specimen. If the forces which restore the deformation are proportional to the amplitude of vibration and if the dissipative forces are proportional to the velocity of deformation, conditions which often apply, then the ratio between successive free oscillations of the specimen is constant and the natural logarithm of this ratio—that is, the logarithmic decrement—is constant and may be taken as a measure of the internal friction.

Another, less direct, measure of internal friction is given by the sharpness of the resonance curve under conditions of forced oscillation. If a specimen is driven by a force of fixed amplitude and variable frequency, and if the amplitude of vibration of the specimen is plotted against frequency, the curve shows a maximum close to the resonant frequency f and falls off on either side of it. The lower the internal friction, the sharper this resonance peak is found to be, and if Δf is the change in the impressed frequency necessary to change the amplitude from half its maximum value on one side to half its maximum value on the other, then $\Delta f/f$ is also a measure of the internal friction. The ratio $\Delta f/f$ for low damping is equal to $\sqrt{3}/2\pi$ times the specific loss. By analogy with the electrical resonance case, a quantity Q, the "quality factor" in engineering terminology, is sometimes used as a measure of the sharpness of the resonance curve. The relationships between the quantities mentioned so far are

$$\frac{1}{Q} = \frac{\Delta}{\pi} = 2\pi \left| \frac{\Delta W}{W} \right.$$

These methods of specifying the internal friction apply most naturally to experimental techniques in which the solid specimen is made to oscillate at or near its natural frequency—that is, with the acoustic wavelength of the same order of magnitude as the specimen dimension. The longitudinal and shear velocities of sound in most solids are of the order of 10^5 centimeters per second. The fundamental frequencies will therefore generaliy be of the order of 10^5 per dimension—that is, about 10^4 cycles per second. Prior to about 1946, most ultrasonic measurements on solids were carried out at such frequencies.

Since the development of radar techniques during World War II, however, measurements of the attenuation of sound in solids can now be made by a

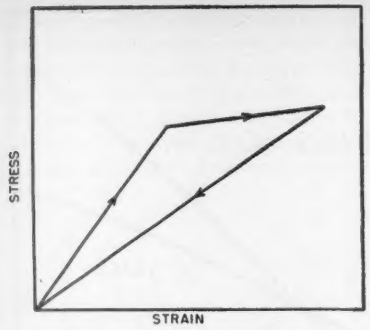

Fig. 4. A stress-strain hysteresis loop giving rise to "anelastic" behavior. The area of the loop represents the energy lost per half cycle by internal friction. This energy is dissipated as heat.

pulse technique. In this method, a pulse of sound, which may be at as high a frequency as 1000 megacycles per second, is injected into the solid specimen by means of a piezoelectric transducer which converts from electrical to mechanical oscillations. After passage through the specimen the acoustic pulse may be again reconverted to an electrical one and viewed on the cathode-ray oscilloscope. The ratio of the amplitude of the emerging pulse to that of the incident pulse gives a measure of the acoustic attenuation in the solid. With such techniques it is common to quote the loss in decibels (db). Thus

$$\text{db/cm} = 20 \log_{10} A_1/A_2$$

where A_1 and A_2 are the pulse amplitudes before and after passage of 1 centimeter through the solid material. The loss in decibels per centimeter can be related to the other measures of internal friction mentioned previously, since

$$\frac{1}{Q} = \frac{2 \text{ (db/cm) (sound velocity)}}{8.6 \text{ (frequency)}}$$

In the remainder of this article I consider the three principal mechanisms by which ultrasonic sound is dissipated in solids and refer to some examples of these mechanisms which have been under recent study.

Ultrasonic Attenuation by Scattering

The scattering of sound in gases by objects whose diameter is less than the wavelength of the sound was studied in 1894 by Lord Rayleigh (*6*). He deduced the law of scattering to be such that the intensity of the scattered sound is inversely proportional to the fourth power of the wavelength. This law is also well known in optics, where light waves are scattered by small particles in the air. It is sometimes also noticed, for example, that the pitch of the echoes returning from, say, a group of trees appears to be raised above the pitch of the incident call. Since the sound in this case is complex, consisting, for example, of a fundamental tone plus a series of higher harmonics, the component tones will be reflected or "scattered" from the trees in increasing proportion toward the higher harmonics.

Similar effects cause the loss of intensity of high-frequency sound propagated through a polycrystalline solid when the wavelength of the sound is greater than a few times the diameter of the individual crystallites. Neighboring grains are, of course, at different orientations, and the elastic properties of crystalline materials are in most cases markedly anisotropic. As a consequence, a sound wave passing from one grain to the next will encounter a change in elastic medium and will be reflected. In the terminology of the electrical engineer, this is an impedance mismatch. The ultrasonic wave is accordingly attenuated, the attenuation being greater in more anisotropic materials. Mason and McSkimin (*7*) have shown that if the wavelength is more than about three times the grain size in aluminum, then the attenuation is inversely proportional to the fourth power of the wavelength, as in Rayleigh scattering. From the characteristics of the scattering process it is sometimes possible to obtain a measure of the size of the scattering particles, and it has been suggested by Roderick and Truell (*8*) that the method may be of use in metallographic examination. This process sets a limit to the usefulness of metals as ultrasonic delay lines at high frequencies. Figure 3 shows the experimental work of Mason and McSkimin (*7*).

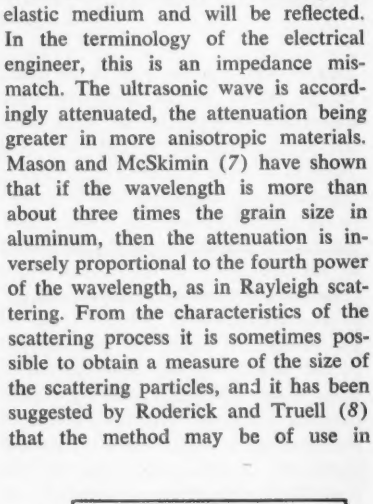

Fig. 5. The effect of compressive stresses on positive magnetostrictive or electrostrictive materials. The arrows inside the two pairs of adjacent domains show the directions of polarization within the grains. Stresses have little effect on domain walls parallel to them but enable perpendicularly polarized domains to grow. The new positions, under stress, of the domain walls are shown by the dashed lines.

Hysteretic Ultrasonic Attenuation

The truth of Hooke's law, *"ut pondus sic extensio"*—that is, the stress applied to a material leads to a proportional strain or deformation—has been widely challenged in recent years with the introduction of more refined measuring techniques. The subject of elasticity, which evolves from the assumed truth of this law, is still, however, of great importance. The deductions are sufficiently good approximations for most work of a technological nature, although interesting departures have recently been successfully made in building construction. The laws of elasticity still serve, and will probably always serve, as mathematical models against which the actual behavior of materials can be judged.

Except, however, at very small stresses, the strain in most solids is not a single-valued function of the stress applied. The strain does not follow the same path when the stress is reduced from a certain value as it does when the stress is increased from zero. A stress-strain hysteresis loop is formed, and the area of the loop represents mechanical energy which has been lost in the form of heat. This is known as "anelastic" behavior; development of the subject owes much to the work of Clarence Zener (*9*). Figure 4 shows a possible stress-strain cycle.

A number of recent investigations of acoustic loss in solids have revealed hysteretic mechanisms. One important class of phenomena of this nature is the amplitude-dependent loss in ferromagnetic and ferroelectric materials. These solids are respectively characterized by "domains" or regions in which the magnetic and electric polarization is in a single direction. If a ferromagnetic or ferroelectric material is placed in either a magnetic or an electric field, then the increase in over-all polarization is brought about by the growth of domains oriented in the direction of the field, at the expense of other domains less favorably oriented. A certain level of field energy is necessary to move the domain wall, and hence if the field is cycled, the field polarization rela-

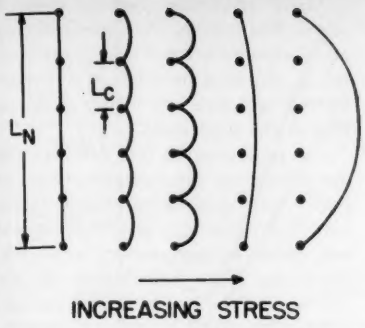

Fig. 6. The successive drawings indicate schematically the bowing out of a pinned dislocation line by an increasing applied stress. The length of loop determined by impurity pinning is denoted by L_c, and that determined by the net work, by L_N. As the stress increases, the loops L_c bow out until breakaway occurs.

tionship is in the form of a loop. The area of the loop represents the energy expended in polarization.

Such changes in polarization are accompanied, because of magnetostriction or electrostriction, by changes in the separation of atoms in the domain. Conversely, when a stress is applied to a ferromagnetic or ferroelectric material, a change in polarization of the domains is brought about. It turns out that domains which are polarized at right angles to the stress tend to grow at the expense of others not so directed. These changes are shown in Fig. 5. The hysteresis loss is dependent on the amplitude of the applied stress and should be independent of the frequency for cyclic stresses up to a limit when the domain wall is unable to move fast enough to follow the stress. The attenuation due to the hysteresis loss should then disappear.

Another type of hysteresis loss which is not yet fully understood, and which is under study in a number of laboratories, is concerned with the motion under cyclic stresses of dislocations in solids. For strain amplitudes of up to about 10^{-4} and at frequencies usually of the order of 10^4 cycles per second, it has generally been found that the internal friction in metals at room temperature and lower is, in accord with a hysteretic mechanism, frequency-independent and that it increases monotonically with stress. At stress levels beyond which dislocations increase rapidly in number, the internal friction rises sharply.

There has been much speculation about the mechanism which accounts for the internal friction at low amplitudes and at temperatures at and below room temperature (*10*). The model which appears to be most successful is that proposed by Granato and Lücke (*11*), shown in Fig. 6.

The single metallic crystal is assumed to contain a network of dislocations, with the network locking points strong enough to resist breakaway under stresses within the hysteretic loss range. The dislocations are further pinned by impurities. It can be seen from the structure of an edge dislocation (Fig. 1) that hydrostatic stresses around the dislocation may be relieved by a suitable arrangement of nearby solute atoms. Assuming therefore, that the necessary diffusion of impurities is possible, we can postulate that each dislocation gathers round itself an "atmosphere" of solute atoms. At a particular temperature, therefore, we have a typical dislocation length locked at its ends firmly enough to resist the stress applied and less firmly pinned at intermediate points by impurity atoms. As the stress is increased, the dislocation bows out as shown, and deformation strain occurs. At a particular value of stress the loop breaks from an impurity pin and the consequently enlarged loop then tears away from the remaining impurity pins until the network length is reached. At this point the strain increases with little extra stress. The return part of the cycle, with the stresses being reduced, causes the dislocation to collapse until pinned again by the impurities. A stress-strain hysteresis loop similar to that shown in Fig. 4 is thus formed, and the energy lost to heat per cycle is again equal to the area of the loop.

The inherent difficulties in this model, which has had general success, lie in the mechanism of loss due to dislocations which are initially not pinned by impurities and in the choice of distribution function of dislocation loop lengths. A pinning point which resists the greatest stress applied at one temperature may of course be weakened sufficiently to break at a higher temperature. This modification and the detail of the nature of the loss once the pins have broken have been studied by Rogers and Hutchison (*12*).

Relaxation-Type Ultrasonic Attenuation

I shall now discuss the third and perhaps the most important class of mechanism which gives rise to acoustic attenuation in solids. In this class the solid is regarded as a system which, when subjected to a sudden stress, relaxes that stress at a characteristic rate. The rate depends on the specific nature of the relaxation process and invariably involves the transfer from one configuration to another of some internal imperfection of the solid lattice. Relaxation processes are associated with each of the imperfections discussed above. Specific models can be set up for each of the processes, such as relaxation by stress-induced interstitial diffusion, relaxation by dislocation motion, and so on. On the other hand, a good introduction to the subject can be made by setting up a general phenomenological model and deducing the basic nature of relaxation damping. To set up a detailed model for a specific process is then more meaningful. This is the plan

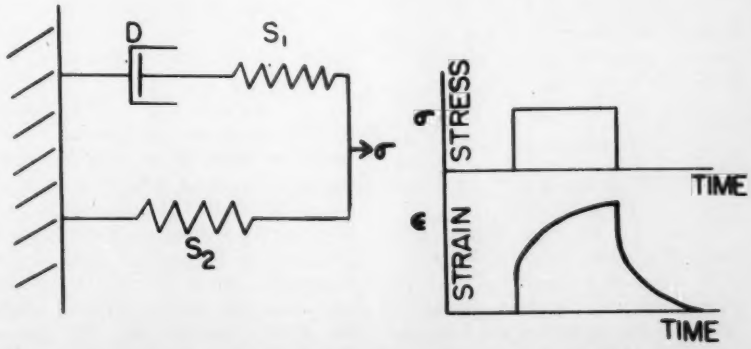

Fig. 7. The "standard linear solid." S_1 and S_2 are springs, while D is a dashpot arrangement. The diagram at upper right shows a stress σ which, when applied to the standard linear solid, produces the subsequent displacement or strain ϵ shown in the diagram at lower right.

I follow in the remainder of this article.

The most generally successful mechanical model which has been proposed to simulate the stress-strain behavior of real solids is that proposed by Zener (*9*). It is called the "standard linear solid" and is shown in Fig. 7. The model consists of the parallel arrangement of spring S_2 and spring S_1-dashpot D.

Suppose a stress σ is suddenly applied; then the system will have an instantaneous displacement or strain ϵ, depending solely on the spring constants. If, however, the stress is maintained, then the dashpot relaxes, increasing the over-all strain. Conversely, when the stress is suddenly removed, the springs will release some of their stored energy and this will result in a partial instantaneous recovery. The complete release of all the energy in the springs must await the gradual relaxation of stress across the dashpot. The general features of elastic aftereffects in real solids are thus given by the model, in which both the strain and rate of strain are dependent on the stress and rate of stress.

It may now be of interest to the reader with a background in the mathematical sciences or in engineering to actually work out the solution of the differential equation which expresses the strain and rate of strain as a function of the stress and rate of stress. The method used is of wide application in electrical engineering.

If σ, $\dot{\sigma}$, ϵ, and $\dot{\epsilon}$ are the stress, rate of change of stress, strain, and rate of change of strain, respectively, then the behavior of the standard linear solid is given by the equation

$$\sigma + \tau_\epsilon \dot{\sigma} = C(\epsilon + \tau_\sigma \dot{\epsilon}) \qquad (1)$$

where C, τ_ϵ, and τ_σ are constants.

The nature of τ_ϵ and τ_σ is shown by making, for example, a test of the equation under conditions of constant strain. Let us say that $\epsilon = 0$. Then Eq. 1 reduces immediately to

$$\sigma + \tau_\epsilon \dot{\sigma} = 0$$

The solution of this simpler equation is $\sigma = \sigma_0 e^{-t/\tau_\epsilon}$ where t is time.

Hence τ_ϵ is the time which elapses between a stress value of σ_0 and a stress value of σ where $\sigma_0 = \sigma \times e$. In other words, τ_ϵ is the time constant of the circuit for constant strain. Likewise, τ_σ is the time constant of the circuit for constant stress.

Suppose the stress and strain are both periodic, as they are in most experimental determinations of internal friction. Let us substitute the periodic solutions $\sigma(t) = \sigma_0 e^{i\omega t}$ and $\epsilon(t) = \epsilon_0 e^{i\omega t}$, where ω is the applied angular frequency. Then Eq. 1 becomes

$$\sigma_0(1 + i\omega\tau_\epsilon) = C(1 + i\omega\tau_\sigma)\epsilon_0$$

The value of stress/strain or the "impedance" Z is now

$$C(1 + i\omega\tau_\sigma)/(1 + i\omega\tau_\epsilon)$$

Finally, the dissipation loss $1/Q$ (internal friction) is given by

$$\frac{\text{imaginary part of } Z}{\text{real part of } Z}$$

That is,

$$\frac{1}{Q} = \frac{\omega(\tau_\sigma - \tau_\epsilon)}{1 + \omega^2\tau_\sigma\tau_\epsilon}$$

or

$$\frac{1}{Q} = (\text{approx. constant})\left(\frac{\omega\tau}{1 + \omega^2\tau^2}\right) \qquad (2)$$

where τ is the geometric mean between τ_σ and τ_ϵ.

Let us now see how the internal friction $1/Q$ varies with the angular frequency ω for different values of relaxation time. The $1/Q$ versus $\omega\tau$ relation of Eq. 2 is drawn in Fig. 8. The internal friction maximum, at a value of $\omega\tau$ equal to unity, shows an important characteristic of a relaxation mechanism which makes it amenable to test by ultrasonic techniques. If the angular frequency of the applied stress in the experiment equals the inverse of the relaxation time of the system to which the stress is applied, then the system absorbs the maximum amount of acoustic energy, the dissipation loss falling off sharply with frequency above and below the critical value.

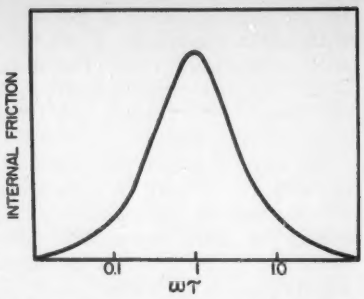

Fig. 8. Variation of internal friction with $\omega\tau$ for a relaxation process when ω is the applied stress frequency and τ, the time of relaxation of the process. The maximum at $\omega\tau$ equal to unity is characteristic of a relaxation process.

Many relaxation systems exist in solids. Their study by acoustic attenuation experiments has been most fruitful in obtaining information about the internal structure and modes of relaxation of the solid itself.

Let us choose as our first example the nature of thermoelastic losses in polycrystalline metal specimens; this is easy to understand in general terms and will serve as introductory relaxation theory for those readers who did not care to read the mathematical analysis.

When a crystal is stressed suddenly its temperature changes, the temperature of the parts of the crystal under compression being raised and of those under tension being lowered. Since the stresses in polycrystals are not uniform but vary from grain to grain, it follows that in these the temperature resulting from this thermoelastic effect also varies from grain to grain. Now, if the stresses vary slowly as compared with the time required for heat to flow between regions having different temperatures, the temperature remains constant and the transfer of mechanical energy into heat, and vice versa, takes place reversibly. There is then no contribution to the internal friction. Similarly, if the vibrations in stress take place so rapidly that no heat flows during a stress cycle, the process occurs adiabatically, for every grain behaves as if it were thermally isolated. It follows that the net conversion of elastic energy into heat during a complete cycle is also zero in this case. At intermediate frequencies there is a finite contribution to the internal friction from the thermoelastic effect.

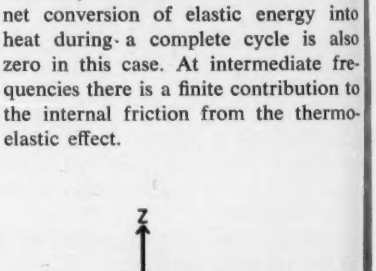

Fig. 9. Unit cell of body-centered cubic iron. When the cell is elongated by stress in the Z direction, the favored positions for interstitial carbon atoms are C_1 and C_2.

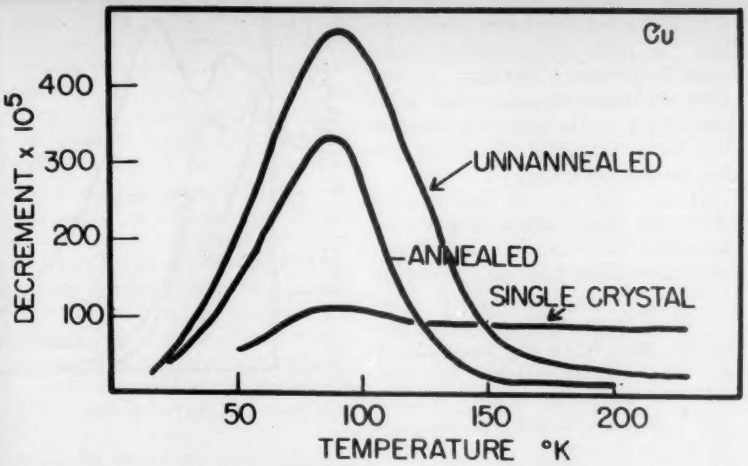

Fig. 10. The Bordoni internal friction peak in copper at a frequency of applied stress of 30 kilocycles per second. A reduction of the degree of cold working of the specimen (by annealing) also reduces the height of the attenuation maximum but does not alter the temperature at which it occurs.

Zener, in his discussion of this problem (*9*), showed that the thermoelastic contribution to the decrement Δ is given by three factors,

$$\Delta = R \cdot \Delta_E \cdot \Omega$$

The factor R depends on the anisotropy of the grains and is greater for the noncubic metals. The factor Δ_E is called the relaxation strength and contains the plausible quantities, compressibility, thermal expansion coefficient, specific heat, and temperature. The frequency factor Ω equals $\omega\tau/(1+\omega^2\tau^2)$ where ω is the applied angular frequency of the stress and τ is the time for heat to flow at the temperature of the specimen across neighboring grain boundaries. The variation with frequency of the thermoelastic damping will therefore be of the form shown in Fig. 8. Naturally τ contains the grain size and the rate of diffusion of heat. The correctness of this interpretation of damping maxima found in brass specimens of different grain sizes was quantitatively confirmed by Randall, Rose, and Zener (*13*) when they correctly deduced the grain sizes from the frequencies of maximum attenuation.

Measurements of internal friction have also been of great importance in the investigation of the motions of interstitial and substitutional impurity atoms. Much of the theoretical development of the subject is again due to Zener, while detailed systems have been studied by Snoek (*14*) and Dijkstra (*15*).

Let us examine the motion under thermal activation of carbon and nitrogen atoms in body-centered iron. The interstitial positions which these atoms occupy are the face centers and midpoints of the edges of the body-centered cubic cell. Such positions are midway between the iron atoms. Since the lattice is cubic, all of the face centers and edge mid-points are equally favored, and equilibrium between the positions is established by thermal agitation. Suppose, however, that a stress is applied to the cell in the Z direction (see Fig. 9) which causes the iron atoms to move further apart along that axis. The favored positions for the carbon or nitrogen interstitial atoms will then be positions such as C_1 and C_2. In order to move to C_1 and C_2, the interstitial carbon or nitrogen atoms must have thermal energy imparted to them equal to the activation energy for the change in position. The average time τ that elapses between jumps for a specific carbon atom is given by the Arrhenius type equation

$$\tau = \tau_0 e^{18,000/RT}$$

where τ_0 equals 0.45×10^{-13} second, R is the gas constant (= 2 calories per mole per °K) and 18,000 calories per mole is the activation energy for the carbon jump. At a temperature of 300°K we have, therefore, τ equal to about 0.5 second.

Observations of the internal friction in steel wires, in slow-oscillation experiments with periods of about 0.5 second, should, therefore, disclose the relaxation damping due to the motion of the interstitial carbon atoms.

It is obvious that the attenuation at a fixed frequency will fall off rapidly as the temperature is decreased or increased from the value where the damping is a maximum. Suppose, for instance, that the temperature is raised in the steel specimen by 50°K while the period of oscillation remains about 0.5 second. Then τ has the new value of 0.005 second, and the value of the internal friction, as determined from a consideration of the frequency factor discussed above, would fall to about 2 percent of its value at 300°K.

A further simple calculation also shows that raising the temperature at which the experiment is conducted from 300° to about 450°K and above would bring the search for the attenuation maximum into the ultrasonic region.

There are many such relaxation processes in nature, with the reordering of the solid taking place under thermal action and obeying an Arrhenius-type law, as in Eq. 3. Stress relaxations are caused by slip at grain boundaries, slip at twin boundaries, reorientation of pairs of solute atoms, reorientation of point defects, molecular motions in polymers, and so on.

An interesting use of the technique of following the mobility of interstitial atoms in steels by attenuation measurements has been made by Harper (*16*). He was concerned with the study of a phenomenon known as strain aging, in which a steel that has been allowed to age for various periods of time at room temperature acquires a degree of brittleness which renders it useless for stamping operations. As one can imagine, the havoc wrought in the raw-material logistics of many industries has made the study one of major technological importance.

Harper was testing a theory of the strain-aging process developed by Nabarro, Cottrell, and Bilby (*17*), in which they regarded the process as one in which solute atoms migrate towards free dislocations at rest in an overstrained crystal and anchor the dislocations by forming atmospheres. The dislocation slip process is then inhibited, and the material becomes brittle. Harper used internal friction measurements, similar to those described above, to determine the amount of carbon remaining in random solution—that is, not settled on dislocations. He made this

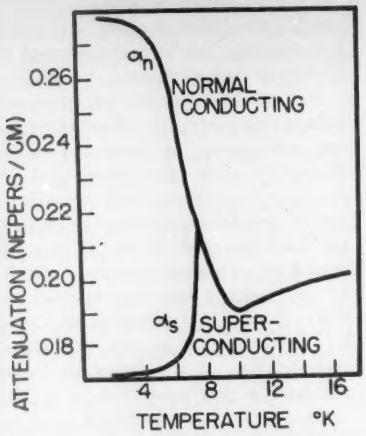

Fig. 11. The increase at low temperatures of the attenuation of sound of high frequency. The applied frequency is here 26.5 megacycles per second; the specimen is fairly pure lead. Below about 7°K the lead becomes super-conducting and the attenuation falls rapidly (α_s). The normal conducting state may be restored below 7°K by a magnetic field, and the attenuation values α_n obtained.

determination after aging the steel for different times at different temperatures and was able to confirm the predictions of the rate at which strain aging takes place.

It is not too surprising that a serious search for relaxations in solids by measurements of acoustic attenuation had not been extended to low temperatures until quite recently. It was believed that the internal friction fell off with temperature and approached zero at 0°K. This is in general true. As the lattice energy falls off quite rapidly below about one-third of the Debye temperature (see Fig. 2), it was not expected that relaxation processes, which in general are thermally activated, would appear at low temperatures.

However, in 1954 Bordoni (*18*) reported measurements of the internal friction of several metals at frequencies of about 40,000 cycles per second and at temperatures from 4°K up to room temperature. He found a large absorption peak at temperatures around 100°K; for copper, for example, at 30.3 kilocycles per second, the peak temperature was 90°K. The height, but not the position, of the peak was increased by small amounts of plastic deformation of the specimen. Annealing at high temperatures reduced the magnitude of the attenuation maximum. Figure 10 shows a plot of internal friction against temperature for copper in various conditions. Other measurements (*19*) at different frequencies have shown that the peaks are relaxation peaks, since the frequency and peak temperatures are related by an equation of the type of Eq. 3. The activation energy is low, being about 2000 calories per mole for the different metals.

Mason (*20*) at first believed that dislocation loops, whose lengths were defined by the distance between points where the dislocation was pinned by impurity or structural defects, were oscillating under thermal agitation at a definite rate. When the frequency of the applied stress matched this rate, then the relaxation internal friction would be a maximum, as discussed above. The temperature of the damping maximum was, however, shown to be independent of the amount of plastic deformation and impurity content and condition. Since such changes would certainly vary the loop length between locking points, Mason's theory appeared to be untenable. Seegar (*21*) has proposed an important modification of the Mason model, in which it is suggested that only portions of the dislocation loops, known as "kinks," move under thermal influence and so account for the relaxation process. The relaxation temperature is thus a characteristic of the dislocation itself and is independent of the nature and number of the impurity or structural locking points.

The dislocation relaxation mechanisms are not confined to metals but have also been found in natural and synthetic quartz, the wide use of the latter as crystal oscillators making the phenomenon one of technological concern.

The use of high-frequency pulse techniques for measurement of ultrasonic attenuation has recently revealed an entirely new kind of damping in metals at low temperatures. This is due to an interaction between the lattice, which is oscillated with the sound wave, and the conduction electrons of the metal. At very low temperatures, let us say at 1°K, the "mean free path" of the electrons has increased to perhaps 10^4 times its value at room temperature and may be up to about half a millimeter in very pure materials. Since the velocity of sound in metals is about 5×10^5 centimeters per second, the mean free path in such pure metals would equal the acoustic wavelength at a frequency of about 10 megacycles per second. Equipment is now readily available to study attenuation with acoustic wavelengths

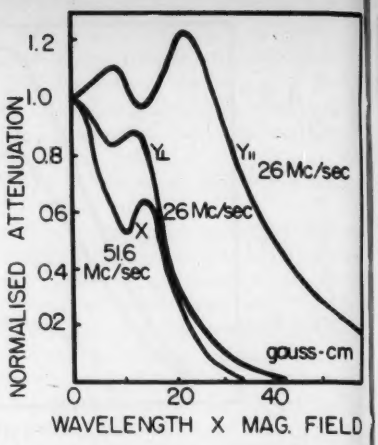

Fig. 12. The variation at liquid helium temperatures of normalized acoustic attenuation in pure copper is shown plotted against the product of wavelength and magnetic field. X denotes longitudinal waves and Y_L, shear waves with the magnetic field perpendicular to both the direction of the wave and the plane of polarization, while Y_{II} had the magnetic field in the direction of the polarization vector. Maxima and minima of attenuation occur for certain coincidences of electron orbit diameter and acoustic wavelength.

greater than and less than the electronic mean free path.

Bömmel (*22*) and, independently, MacKinnon (*23*) first discovered that the ultrasonic attenuation increases at very low temperatures. Bömmel's results for lead are shown in Fig. 11. It is probable that the acoustic wavelength in this work was greater than the electronic mean free path, since the lead was not of the highest purity. The attenuation has been shown for this condition to be proportional to the mean free path and, consequently, to the electrical conductivity, and also to vary as the square of the applied frequency. While Mason (*24*) has proposed a theory that the attenuation is due to a transfer of momentum from the lattice to the electron gas and a subsequent damping due to the viscosity of the gas, it is possible to regard the process as a relaxation mechanism. Morse (*25*) and Kittel (*26*) believe that a more general description of the mechanism is that of distortion of the momentum pattern of the electrons by the sound wave, this distortion then relaxing by collision of the electrons with the phonons present. The relaxation time is similar to that involved in the process of electrical conductivity. An analysis, which is simi-

lar in form to that given above for a relaxation mechanism, then leads to a relationship between attenuation, frequency, and conductivity which, in the lower limit of $2\pi l/\lambda < 1$ is similar to Mason's. Here λ is the acoustic wavelength and l, the mean free path.

Extremely interesting experimental results have been recently found for the case when the mean free path of the electrons is greater that the acoustic wavelength—that is, $2\pi l/\lambda > 1$—a condition which is brought about by using very pure metals and high frequencies. Some of the results are reproduced in Fig. 12, taken from a paper by Morse, Bohm, and Gavenda (*27*).

It may be seen that the application of increasing magnetic fields to the specimen causes the lattice electron attenuation to oscillate in value. Here the conduction electrons, having long paths, are spiraled round by the magnetic field, and it appears that maxima and minima of attenuation occur for certain coincidences of the electronic orbit diameter and the wavelength.

Another interesting feature of lattice-electron attenuation is apparent from a study of Fig. 11. Below about 7°K the attenuation a_s is seen to fall off very steeply. This occurs at the transition temperature below which lead becomes super-conducting. It is possible to restore the normal conducting state at temperatures below the transition temperature by the application to the specimen of a magnetic field greater than a certain value (*28*). The attenuation rises as a consequence of the metal becoming normal (a_n in Fig. 11), the experimental method thus providing a tool for the study of the phenomenon of superconductivity. Several papers have appeared (*29*) recently in this latter connection, as a result of the recent success of Bardeen, Cooper, and Schrieffer (*30*) in their theoretical attempt to explain superconductivity, a problem which has been extant for some fifty years.

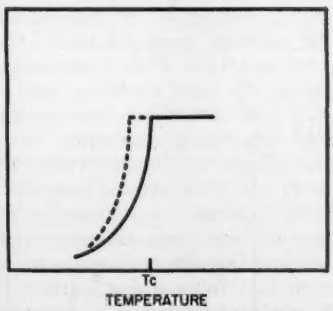

Fig. 13. The expected variation of kilomegacycle frequencies of acoustic attenuation with temperature for a superconductor. Morse has proposed that when $h\nu$ becomes of the order of kT (see text), electron transitions may be induced across an energy gap which, according to Bardeen-Cooper-Schrieffer theory, appears at the transition temperature. The metal specimen would then appear to be normal-conducting to lower temperatures (dotted line) than would be the case at lower frequencies (solid line), when such transitions are impossible.

Table 1. Typical magnitudes for energy associated with very high frequency elastic waves; kT at 1°K $= 8 \times 10^{-5}$ electron volts.

Frequency (Mcy/sec)	Wavelength (cm)	Energy E (electron volts)
100	3×10^{-3}	4×10^{-7}
1,000	3×10^{-4}	4×10^{-6}
10,000	3×10^{-5}	4×10^{-5}

A great difficulty in this work is to know the magnitude of the experimental "background" loss which must be subtracted from the attenuation due to the conduction electrons. This has reduced the value of much of the high-frequency work as a quantitative test for the different theories.

It may be of interest to mention in conclusion an experimental test of the Bardeen-Cooper-Schrieffer theory which should be relatively free from this defect and which at the same time points the way to future ultrasonic research in solids (*31*).

Let us first examine the magnitudes of the energy associated with very high frequency elastic waves. The energy E is given, as for phonons, by $E = h\nu$. Many transitions of electron energy in solid-state physics have been discovered which become possible when the energy E is of the order of kT where T is, as before, the Kelvin temperature and $k = 1.38 \times 10^{-23}$ joule/°K. We have already seen the ratio E/kT appear in the "probability factor" (E/kT) of the Arrhenius equation (Eq. 3). It is perhaps surprising to realize that, with the advent of very high frequency acoustic waves in solids, the value of $h\nu$ is now approaching kT for the attainable low temperatures of 1°K and below. Some typical magnitudes are shown Table 1, taken from Morse (*30*).

Normally, electrons have a continuous range of energy values in a metal up to a value known as the Fermi level. There are available energy levels above this value which are normally unfilled. The imposition of an electric field or an acoustic wave can thus transfer energy to the electrons which go partially into the previously unfilled band. Now it is a central feature of the Bardeen-Cooper-Schrieffer theory of superconductivity that around the Fermi level a gap of nonavailable energy levels appears. This gap is of the order of kT in magnitude and increases in width as the temperature falls below the superconducting transition temperature (Tc).

To return now to the experimental test of the theory, it now seems possible at high enough acoustic frequencies to induce electron transitions directly across this gap. The metal would therefore appear to be normal below the transition temperature, and attenuation values would follow the dotted line in Fig. 13. The value of the new temperature at which the attenuation falls discontinuously would also be relatively free from the indeterminate background loss, and the whole experiment, although difficult to perform, should yield quantitative results.

This is merely one of the many experiments which underline the importance of an extension of ultrasonic research into the kilomegacycle region and above. There is no doubt that when directed "phonons" of wavelength short enough to be associated with the phenomena of "thermal conductivity" become available, there will be an exciting harvest to be reaped.

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New Frontiers to Health in Africa

The creation of new, independent states in Africa poses new problems in the eradication of disease.

K. R. S. Morris

Those of us who are working in Africa are being confronted today by a disturbing reversal of the past half century's fine record of progress in the conquest of disease in that continent. The cause lies in the petty nationalisms now arising in new African states. That the effects may be serious, not only for the new countries but for territories far outside their boundaries, can be seen from the example of sleeping sickness.

Epidemics and Their Control

This disease, caused by the protozoan *Trypanosoma gambiense* and carried from man to man by the riverine tsetse flies, *Glossina palpalis* R.D. and *G. tachinoides* West, has been present in West Africa for 600 years (*1*) but only developed into widespread epidemics after 1920, although in East Africa catastrophic outbreaks had occurred in several places just after the turn of the century. These East African outbreaks were due to the introduction of infections from the Congo by travelers and slavers; I have traced (*2*) the spread of a series of epidemics from west to east across Uganda, each following a big population movement. The West African epidemics, greater both in extent and intensity than those of Uganda and Kenya, also followed big expansions in travel, commerce, and agriculture, which accompanied British and French colonization. By 1940, when the epidemics everywhere had reached their peak, there was severe depopulation of large areas, particularly in some of the most fertile and well-watered river valleys of the Volta and Niger systems (*3*). West Africa could ill afford nonproductivity in this territory, since in neighboring, unaffected areas the population was increasing by 10 to 15 percent in a decade and was starting to feel the effects of soil erosion and its associated evils.

This grave situation was tackled in slightly different ways by the governments of various colonial territories, with the French well in the lead, both regarding the scale of operation and the logic and thoroughness of application. The fact that the French had in French West Africa a uniformly administered territory, stretching from Dakar to Niamy on the Niger, made possible such a wide approach, but it took the vision and tenacity of Médecin Général Muraz to make this a reality by creating an autonomous "Service de la Maladie du Sommeil" in 1939, to deal with the whole of French West Africa according to a uniform plan, and the realism of Dr. Jamot to devise a method (mass survey and treatment with mobile bush teams of local natives) which would be effective against such a huge and dynamic problem (*4*). Moreover, Muraz recognized a pattern in the several epidemic areas, placed the headquarters of the Service at Bobo Dioulasso, in the heart of the largest of them, and divided the whole country into sectors of three grades—heavily, lightly, and very lightly infected—so that the degree of attack could be commensurate with the severity of the problem. The emphasis was heavily weighted on the side of chemotherapy, with tsetse fly control as a secondary measure.

In the Gold Coast, affected in the northern part by the huge Volta epidemic, emphasis was placed on vector control, since a method for the complete eradication of *Glossina palpalis* and *G. tachinoides* by selective clearing had been developed there (*5*). In 1940 and 1944, French entomologists visited the Gold Coast to learn this technique, which was then applied in the neighboring territories of the Ivory Coast and Upper Volta. Thus, in French West Africa, with the severely infected areas receiving three to four visits from the survey teams per year and with very thorough treatment and follow-up of patients, the French got their epidemics almost completely under control by 1945, the degree of control being greatest in the heavily infected savanna country of the hinterland, where "le selective clearing" had been most effectively applied, and least toward and in the more lightly infected rain-forest zone nearer the coast, where tsetse control was too difficult to be attempted. The French then introduced mass prophylaxis with lomadine, to deal with the

The author is affiliated with the Liberian Institute of the American Foundation for Tropical Medicine, Harbel, Liberia.

residual endemic foci, with such effect that the number of new cases diagnosed per year in the whole of French West Africa was reduced from its 1941 peak of 29,798 cases to 4873 in 1955.

The extent of the reduction can be seen from a comparison of Figs. 1 and 2. Figure 1, based on Muraz's original survey of 1939, does not show the full extent of the epidemics in Guinea and Upper Volta, where even wider areas of severe infection had developed by 1941. Figure 2 gives the latest available data (1957) for the whole of the French territory; after the secession of Guinea in 1958, information from that colony dried up. However, the maps show well the spectacular success achieved by the French, with reductions of 90 to 99 percent throughout the vast area of the pandemic.

The difficulty of justifying the retention of a large and expensive organization to control a disease which was now of only minor importance was overcome by changing the original "Service Trypano" to "Service Général d'Hygiène Mobile et de Prophylaxie" and using the same very efficient teams and base establishments to diagnose and treat several other serious diseases in addition to sleeping sickness. In this way not only was there a greater degree of public-health improvement but a close watch could be maintained on the trypanosomiasis problem, which, though so greatly reduced, was fraught with explosive possibilities. The wisdom of this step was fully borne out by the results.

Although the approach to the problems of control differed in the Gold Coast, active cooperation with the French was maintained, and antitrypanosomiasis measures were carried out simultaneously on both sides of the frontier. Political frontiers are rarely biological ones. In this instance the Black Volta River divided Ivory Coast from Gold Coast but formed the very backbone of the Volta epidemic. Cooperation was indeed essential for success. The British method of tsetse eradication was slower than the French one of repeated mass treatment and prophylaxis, but in the long run it was more effective and, above all, more permanent. Thus, by 1952, 3000 square miles of severely infected and partly depopulated country had been permanently reclaimed, with consolidation of the clearings and development of the region through farming, grazing, fishing, establishment of markets, and so on (Figs. 3–5).

By 1952, a 99.5 percent reduction in sleeping sickness—virtual elimination—had been effected in the first 1300 square miles reclaimed (the Lawra district), and a 95-percent drop had taken place in the remaining 1700 square miles of Wa district, where a rising

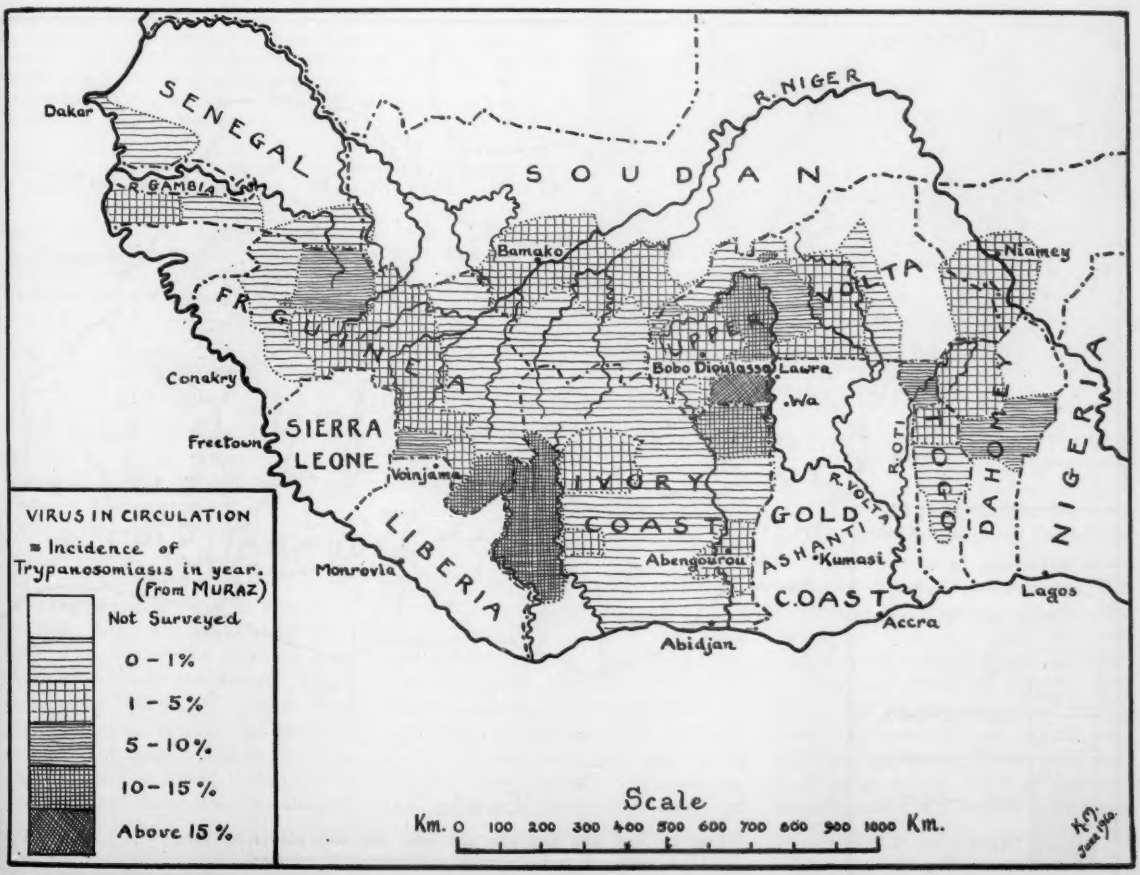

Fig. 1. Incidence of trypanosomiasis in French West Africa in 1939, before control measures had been undertaken.

epidemic had been still active in 1947. Moreover, in the Gold Coast a campaign of focal attack had now been put into operation (*1*), based on recognition of a pattern of true endemic foci, with high infection rates, from which movement of the local people and of traders and travelers caused an outward spread of infection and the setting up of peripheral, secondary areas of much lighter infection, particularly along trade routes. It was held that elimination of the vectors, and therefore of trypanosomiasis in these true foci, would result in the spontaneous reduction or even disappearance of the disease in the secondary areas also, making control there much easier and perhaps unnecessary. The success of this plan, with the Lawra-Wa foci showing high rates of reduction by 1951 and a simultaneous reduction occurring, without the application of any anti-tsetse measures, along the trade route from the Lawra and Wa districts to northwest Ashanti, 300 miles to the south (*6*), showed the validity of the concept. It also underlined the importance of population movements in the epidemiology of trypanosomiasis.

It is obvious that such an attack can only succeed if it is carried out logically over the whole of an endemo-epidemic area. Unfortunately, when I left the Gold Coast in 1952 this plan had been abandoned for one of small scattered clearings, a policy already shown to be ineffective against epidemic trypanosomiasis (*7*). The northwestern area of eradication has remained free, but elsewhere endemics have persisted, with occasional local outbreaks. A reversal of the original picture has, in fact, taken place: the main foci are now to the south, in Ashanti, from where the disease is being carried back into the savanna country of the north (*8*).

Changed Pattern in West Africa

The campaign of the French was designed to cover all their endemo-epidemic areas, as far as international boundaries permitted. While this spectacular control of the epidemics was being achieved, the pattern changed completely, as in the Gold Coast (now Ghana). The fierce outbreaks of 1930 to 1940 reached their full extent in the dry savanna country of the upper Niger and Volta rivers, with high rates of infection occurring right up to the northern limit of the range of the tsetse fly (*1*). The denser vegetation zones of the forest and coast showed much lighter infection or none at all. Today the active foci are located mainly in and around the forest and coast, the great inland savanna region being almost free, with the exception of a small residual endemic in northwest Dahomey and a larger one on the Niger

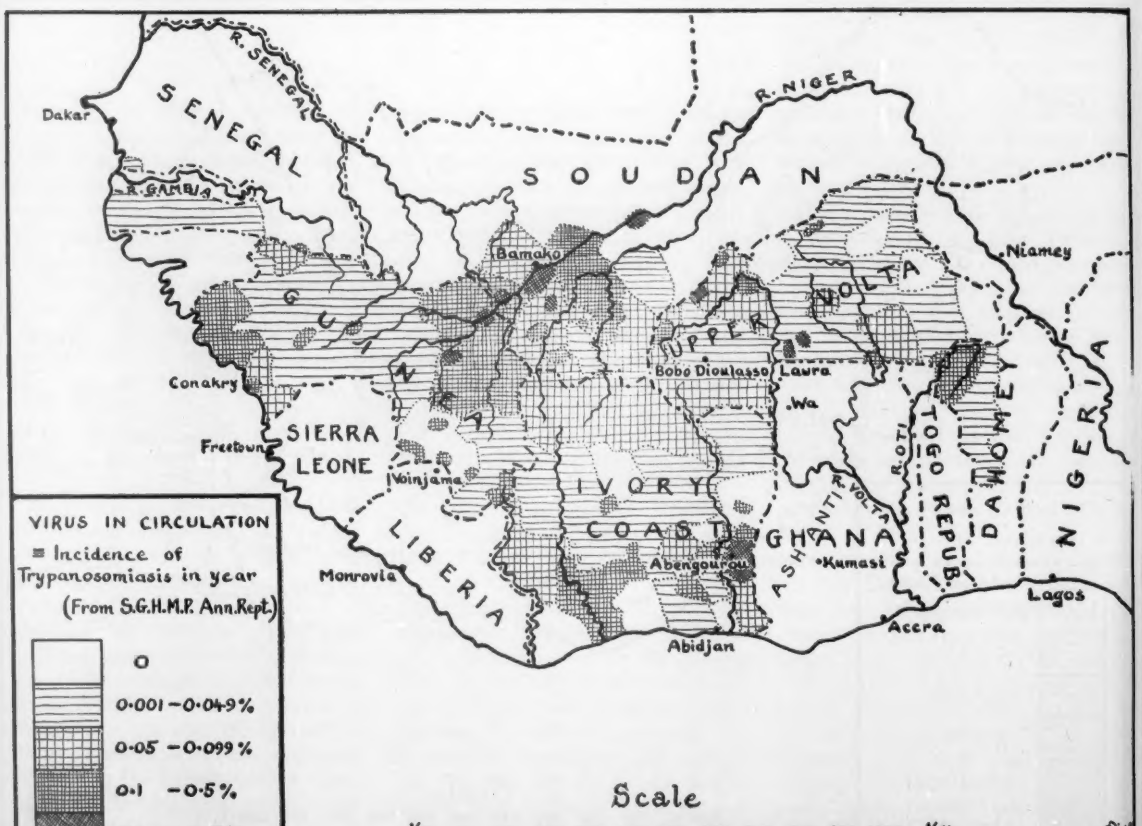

Fig. 2. Incidence of trypanosomiasis in French West Africa in 1957, showing the results of control measures.

Fig. 3 (top left). Selective clearing in the northern part of the Gold Coast in 1945. The large and valuable trees, such as mahogany, are preserved; the dense evergreen shrubs and smaller trees are removed. By this means the tsetse fly was almost completely eradicated from 3000 square miles of the Lawra and Wa districts, where there had been a serious epidemic of sleeping sickness in 1939.

Fig. 4 (top right). A river valley in the northwestern section of the Gold Coast after selective clearing.

Fig. 5 (bottom right). A river valley of the Gold Coast in an area which had been depopulated by a severe epidemic of sleeping sickness. After selective clearing the region was developed through grazing and farming.

around Bamako (compare Figs. 1 and 2).

Examination of the present-day endemics is illuminating.

The northwest Dahomey focus. This focus lies along the frontier with the new Togo Republic, in the upper Oti valley, where tsetse control cannot be complete, since the main river is in Togo. This focus has persisted since 1939, and though the present annual incidence of 100 to 200 cases marks a great reduction, it falls far short of eradication. Failure is due to the local tribes' refusal to attend inspections or even to have lomadine inoculations, the position being aggravated by proximity to the Togo Republic.

The Niger and tributaries around Bamako. This is another endemo-epidemic area of long standing, never completely controlled, with a sharp increase around Bamako itself, the incidence of 460 new cases in 1955 having risen to 718 in 1956, 800 in 1958, and 753 in 1959. Factors leading to the recent outbreak and its persistence are: (i) intimate contact between *Glossina palpalis* and man on the Niger and its many fly-infested tributaries, the sole water supplies in this dry savanna terrain; (ii) recent great expansions in population, trade, and traffic in Bamako and the surrounding villages, causing greatly increased contact between *Glossina* and man and accelerated dissemination of infection (Figs. 6 and 7); (iii) dislike on the part of the population of examination or lomadine prophylaxis and an alarmingly high rate of absenteeism (up to 60 or 70 percent) from surveys. In the absence of tsetse control, this rate of absenteeism is a serious threat to the success of the program. Of the 800 cases in 1956, only 272 were found by survey teams, the rest having been diagnosed at hospitals, dispensaries, and so on, often in an advanced stage —that is, after they had been accessible to the local tsetse for months, even years. That cases were missed in regularly conducted surveys was dramatically demonstrated by the diagnosis, in 45 days during 1957, of 117 trypanosomiasis cases among passengers on the Bamako ferry—nearly three a day!

On the coasts of Senegal, just south of Dakar, and of the Ivory Coast west

of Abidjan. Here small foci of 100-odd cases annually persist, largely because of the obstinate refusal of the population to cooperate in survey and prophylaxis programs.

In a 400-mile strip of Guinea, north of Sierra Leone and Liberia. This has been an endemic area since 1944, showing a disquieting increase and eastward extension into the Ivory Coast in 1957. Tsetse control in this semi-forest country was too difficult to be attempted. The recent outbreaks are due to increasing opposition of the Guinea populations, culminating in the complete immobilization of work through a strike of the hygiene service staff in 1957. Of the 782 cases diagnosed in that year, four-fifths were in advanced stages, the patients having refused to come in earlier, thereby constituting a menace to themselves and to their neighbors. The secession of Guinea in 1958 put an end there to the organized and well-coordinated services of the hygiene teams—services which have not been replaced. The Ivory Coast outbreak was almost completely under control by 1960, after repeated mass surveys and prophylaxis. No information is obtainable from Guinea, but in view of the fact that trypanosomiasis in this dangerously endemo-epidemic area was held in check only by unceasing and well-coordinated action by the French, without their services recrudescence is a certainty.

In the lower Ivory Coast. A serious endemic, with recent annual indices of 850 to 900 cases, has arisen around Abengourou, adjoining the Ghana border, in a forest area of great development, with extensive coffee and cocoa farms run by northern labor from Upper Volta and Soudan. When these latter territories were heavily infected (1934 to 1944), much infection was introduced into the forest by this migrant labor. The position is now reversed: the north is free; the southern endemic has shown a marked increase. The impossibility of tsetse fly control, the difficulties of reaching, diagnosing, and treating or protecting the mass of constantly shifting workers and petty traders, and the recent developments in farming, trading, and general traffic have combined to give rise to a serious problem today. The proximity to Ghana, with endemic trypanosomiasis in Ashanti and continual movement of natives across the frontier, aggravates the difficulties of control. French examination posts on the frontiers between Upper Volta and Ghana and Upper Volta and the Ivory Coast confirm the belief that infection is being transported by workers returning from Ashanti and the southern Ivory Coast.

In general, the territory in which eradication of sleeping sickness has been most nearly achieved is that in which some of the most severe and explosive epidemics took place but where tsetse fly control was understood and was courageously and effectively applied. Where there have been no attempts at entomological control, because it was considered impossible or too difficult and costly (in the forest zone), or where it was possible but not used (around Bamako), incidence of the disease has often been remarkably reduced but there has always remained a low, apparently irreducible minimum at which it was held only by vigilant application of mass treatment and mass prophylaxis, with the slightest interruption resulting in a recrudescence.

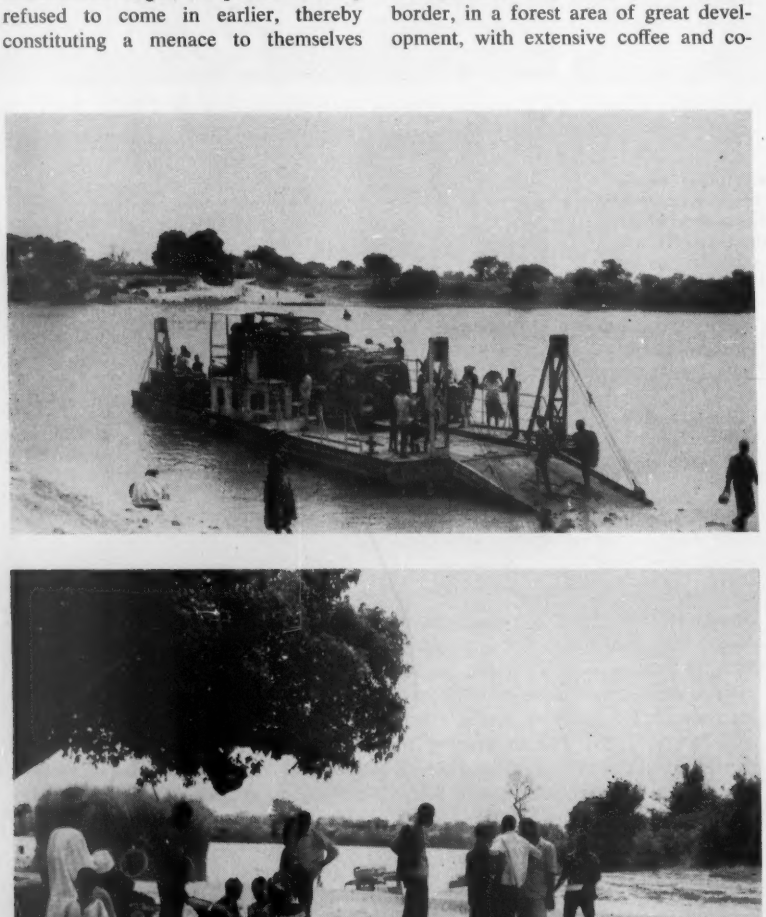

Fig. 6 (top). A ferry on the Niger above Bamako. Fig. 7 (bottom). Passengers and drivers waiting for the ferry near Bamako. A small market always develops at these ferries. Here the people are dangerously exposed to infection from the riverine tsetse flies, which breed in the evergreen vegetation along the river banks.

The New Frontiers

The value of these experiences is that they underline certain principles in the control of vector-borne disease from which future trends can be forecast.

Eradication of the disease can be achieved by vector control alone, if the control is complete; or by partial vector control plus chemotherapy, provided the attacks are well planned and simultaneous.

Chemotherapy alone brings great reduction but rarely eradication. When

chemotherapy is followed by chemoprophylaxis, eradication has been achieved but the situation is unstable, and with the vector still present there is danger of reintroduction and renewed outbreaks. Moreover, this procedure is absolutely dependent on coercion or cooperation of the population, and without this it breaks down. Even with full local cooperation the procedure involves constant attention to suspected areas by reliable and highly efficient teams. Relaxation of this vigilance results in rapid deterioration of the situation and renewed outbreaks.

One other factor, operating with increasing tempo today to hinder the eradication of trypanosomiasis and even to promote new outbreaks, is the amount of development taking place all over Africa. There are three important results: (i) Big increases in the amount and ease of transport (Fig. 8) make medical control of itinerant laborers, merchants, and others almost impossible and, as the whole history of sleeping sickness shows, greatly promote the spread of infection; (ii) new concentrations of people arise, which may lead to epidemic outbreaks if the people come in contact with *Glossina*; (iii) the clearing of forest and extension of farming can restrict the tsetse fly's range and force it into dangerously intimate contact with man.

The point that stands out in this analysis is the need for a greater degree of tsetse fly control to overcome the impasse of lack of popular support and the trends favoring transmission and spread. Control of the vectors in savanna country is well understood and needs only wider application. Forest and semiforest regions present greater difficulties, but these are not insuperable. Ten years ago the possibility of controlling *Glossina palpalis* in the high forest was demonstrated at Kumasi (*9*), and work that I am now doing in Liberia shows that rapid reduction of the same fly around forest villages can be effected by trapping (Fig. 9). There is also the striking success with sprays obtained by the Tsetse Control Department in Uganda (*10*). Control in forest will, however, always be costly, and the problem is likely to be more than local; this means that, to be effective, vector control must be combined with mass treatment and prophylaxis.

The French came very near to achieving their aim of eradicating sleeping sickness throughout French West Africa. Today, in addition to the difficulties intrinsic to the problem, they are faced with that most formidable obstacle —new political frontiers. Frontiers themselves, as Waddy has shown (*11*), are inconsistent with effective control of Africa's major diseases, a fact amply illustrated by the French experiences with trypanosomiasis. The French have also shown how dependent success is upon the meticulous planning and execution of a campaign down to its smallest detail. However ready the new na-

Fig. 8. A bridge under construction over the Lofa River in northern Liberia. The contracting firm, Raymond Concrete Pile Company, has recently built 300 miles of first-class road into the hitherto almost inaccessible hinterland. Developments such as these, which are going on all over West Africa, bring great benefits but also stimulate the spread of sleeping sickness. The riverine forest vegetation surrounding this bridge held dense populations of *Glossina palpalis*.

Fig. 9. A danger spot in the Guinea forest zone at Voinjama in northern Liberia, close to the Guinea frontier. The dense riparian forest is the habitat of *Glossina palpalis*, and sunny openings at water holes, bridges, and fords, where there is an abundant supply of human food, are the flies' feeding grounds. However, trapping by means of the Morris trap, shown here, has effected reductions of as much as 70 percent in the *Glossina* population.

tions may be to follow this precedent, it is unrealistic to expect them to achieve the necessarily high standards let alone have the resources in personnel and materials, for a long time. Meanwhile, the generations of a trypanosome are measured in hours, not years; epidemic diseases are no more respecters of time than of international frontiers. If the return of possibly disastrous epidemics is to be avoided, the solution must lie in the action of a body, such the World Health Organization, with the vision and status to put forward a realistic program of eradication on international lines. The aim is not too high; the benefits would be immeasurable.

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Science in the News

The Atomic Airplane: "This Program Has Had a Very Irregular History"

The project to build an atomic airplane is now 14 years old, and in the unarguable words of a House appropriations subcommittee, it has had a very irregular history. To date over a billion dollars have been spent. The Defense Department estimates it will take at least another billion and another 5 years before a plane is actually in the air. The project has understandably become the most controversial in the Defense Department. It has been attacked from one side for not making an all-out effort to get some sort of atom-powered airplane aloft as soon as possible, from a second for trying to build a plane prematurely, and from a third for spending too much money on a project whose achievements, now that the first billion has been spent, are not very impressive and whose long-run value is difficult to define.

The first group of critics draw their strength mainly from the support of Congressman Melvin Price and several other members of the Joint Committee on Atomic Energy. These critics would like to see a plane in the air, any plane. They are willing to settle for what is called a "flying platform"—that is, a machine that may have no function beyond demonstrating that it can get off the ground.

At the moment the flying platform advocates are unhappy. Last summer, in the most recent of the program's many reorientations, the Defense Department decided to do its preliminary testing on the ground. The program is now concentrating on research, and letting the flying platform have only token support. The intent is to put a plane in the air only after an engine has been developed that will keep the plane aloft for a very long time, although probably not at supersonic speeds.

This approach seems to command broad support, not only in the Defense Department, but in the AEC and among the scientific advisory committees that have studied the project. But it is the source of strong feelings among the flying platform advocates. Here are excerpts from an impromptu lecture Congressman Daniel Flood delivered at a House appropriations committee hearing. The witness was Admiral Burke, the chief of naval operations, who has very little to do with the atomic airplanes. But Congressman Flood was sufficiently irritated about the way things were going to make a speech on the subject nevertheless.

"When Secretary Wilson [Eisenhower's first Secretary of Defense] was here a few years ago," said Flood, "I tried to ask him to explore the moon with me or hit it with tin cans, or a slingshot, or something, but hit it quick. He laughed at me and said he was not interested in finding out whether the moon was made out of green cheese. This was about a year before the Russians shot Sputnik. . . . I am having the same attitude with the Department of Defense and everybody down there about a nuclear-powered aircraft. I do not care how big it is, and I do not care how much it costs. I want the Department of Defense to propel an airframe with nuclear power 50 feet off the ground, 20 miles an hour, if need be. But move it. . . . Wilson, wherever he is, may laugh at this and say it does not mean a thing. That is a matter of opinion. This is a horse race. I would like to see the United States propel aircraft by nuclear power first. . . . If you think it has the tremendous psychological advantage or potential impact that I think it has—on a lot of people all over the world—why do you not try harder for it? Why do you not twist somebody's arm?"

Admiral Burke: "Because it costs too much."

Mr. Flood: ". . . That is the end of the argument, not with me but with you people who have the other problems. . . . This statement of mine . . . is treason according to the new line in Washington . . . because the budget is placed before what I think should come first, among other things, including a nuclear powered aircraft."

But Flood's feelings were not shared by many of his fellow members of the appropriations committee, and particularly not by Chairman Clarence Cannon. Most accepted the Defense Department's assurance that the best scientific estimates strongly suggest that a crash program merely to get a plane in the air would be a misuse of money and scientific talent that might be spent better on other research and development projects, including the advanced reactor and engine research at which the program is currently aimed. But a

very sizable minority of the appropriations committee questioned the wisdom of spending so much money on aircraft nuclear propulsion on the grounds that it now seemed to be mainly just research, and that a useful plane was still years away and partly just an incidental by-product of the basic research being done on reactor technology and materials, and above all, of doubtful utility. Because of the heavy shielding it must carry, the atomic plane will probably be inferior to conventional planes in all respects except its ability to stay aloft for perhaps 1000 hours or more. It is a matter of dispute as to how useful it would be to have a plane that could stay aloft 1000 hours.

The project's appropriations are split almost evenly between the AEC and the Defense Department. An appropriations subcommittee, disturbed by the amount of money the program was costing and the lack of easily definable long-range benefits or short-range progress, voted to cut out all of the $73 million recommended for the AEC share. This would have cut the program in half. But the full committee restored most of the money; the vote was 19 to 18. The Senate restored the rest of the money, and last week the House accepted the full figure.

During the hearings last May the House committee did get a commitment from the Defense Department to make some decisions within four months or so and to try to decide which of the alternative approaches now being supported, the indirect or the direct cycle engine, might be eliminated. The four months are now up, but it appears that the principal decision is going to be that it is still too early to decide. Meanwhile the appropriations committee has put a team of investigators to work to try to find out if the taxpayers are getting their money's worth.

The direct cycle uses the heat developed in the reactor to power the engine. The indirect cycle transfers the heat to an intermediary fluid, perhaps liquid sodium, which in turn carries the energy to the engine. The tendency has been to move away from the direct cycle concept being worked on by General Electric, and toward the indirect cycle concept being worked on by Pratt and Whitney.

But even if a decision is made to terminate the G.E. work as part of the atomic-aircraft program, it appears likely that much of it will continue as part of another related program, Project Pluto, an atomic-powered ramjet missile. The Pluto does not require much concern with either of the two great barriers to a nuclear airplane: the need for a high-intensity reactor that will not burn out in a short time and the need for heavy shielding to protect crew and cargo, which makes the plane difficult to fly. The missile, of course, will have no passengers, and heavy shielding is not needed. Traveling at several thousand miles an hour, it will not need a long-lived engine to push it on its one-way trip to a target. So Pluto will probably be the first object to fly under atomic power, perhaps in 1964. The airplane, it is hoped, will follow a year or so later, as may a third project, Rover, the atomic rocket.

In sum, the flying platform advocates are, temporarily at least, losing their battle, and the Congressmen who have doubts about the wisdom of spending such huge amounts of money on the project if it is being directed mostly at basic research and developing the state of the art, rather than at a specific Defense need, are also a little unhappy. But critics, many of them scientists, who have attacked the program as a misguided attempt to try to do first (build an atomic plane) what can only efficiently be done after the state of the art is more advanced are those who seem to be most successful. They have the support of Herbert York, the chief of research and development at the Pentagon, and York has the confidence of the most influential people on Capitol Hill. The current orientation reflects their viewpoint.—H.M.

News Notes

Molotov Named Representative to Atomic Agency as General Conference Opens

Vyacheslav M. Molotov, former Premier and Foreign Minister of the U.S.S.R., has been recalled from his assignment as ambassador to Outer Mongolia to serve as Soviet representative to the International Atomic Energy Agency in Vienna. It has been suggested that he was withdrawn from his Outer Mongolian post, considered a diplomatic Siberia, because as Stalin's closest associate for 30 years he is too much in sympathy with the Chinese Communists, so close to Mongolia.

The 70-nation IAEA is supposed to be nonpolitical and to serve simply as the clearinghouse for information and technical assistance in the peaceful use of atomic energy; nevertheless, frequently the pattern of debate follows that of current international politics. Molotov may be out of favor with Premier Nikita Khrushchev's regime, but he is still one of the Soviet Union's most experienced and effective diplomats. He is already in Vienna preparing his participation in the fourth session of the IAEA's general conference, which opens on 20 September.

Critical Issues To Be Discussed

During the 2-week meeting, several problems of critical importance to the agency's future will be discussed.

One of the issues is that of inspection to see that nuclear fuel provided by the agency is not used for military purposes. Some nations consider an inspection system an invasion of sovereignty, a view that has been supported by the Soviet Union.

The meeting chairmanship is also an issue, even though the chairman serves only for the duration of the session. Last year Georgi Nadjakov of Bulgaria was expected to be elected, but the United States objected to the post's being held by a Soviet-bloc representative and Hiroo Furuuchi of Japan was named instead—an event which led to charges that the agency was dominated by the United States. Nadjakov is again a candidate.

Another controversy, of major importance but the least clearly defined of all, is associated with the agency's role in helping emerging nations. When the agency was founded in 1953, these countries could not obtain fissionable material for peaceful purposes, and one of the new organization's principal functions was to act as a broker for such substances. Now it is relatively easy to procure them directly, without assistance.

A further problem connected with the IAEA's role arises from the growing conviction that atomic power is impractical for many underdeveloped nations, a complete reversal from the hopeful view of 1953. Yet the possession of a reactor has become a matter of national prestige, and this seems to be stimulating both the United States and the Soviet Union to provide technical aid that could be considered more politically than scientifically motivated. When IAEA specialists try to discourage a nation from launching a nuclear program, they are sometimes accused of protecting the monopoly of the major powers.

Shortages of Mathematicians and Radiation Safety Experts Reported

Authoritative spokesmen called attention to this country's acute shortage of mathematicians and of radiation health specialists in statements issued during the last week of August.

Employment Register Reflects Problem

Three major mathematical organizations were holding national meetings at Michigan State University—the American Mathematical Society, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics — and officials pointed out in a press release that the dearth of mathematicians, particularly those with doctoral degrees, was sharply reflected by the employment register. Employers in industry, government, and universities listed some 130 openings, but only about 65 mathematicians indicated that they were looking for new jobs. Furthermore, most of these are already employed, and new vacancies will be created if they change positions.

The openings listed were principally for men with the doctor of philosophy degree in mathematics. Very few of the applicants held more than a bachelor's degree. Industry and government openings for Ph.D.'s start at from $7500 to $9000 per year. For universities, the figure ranges between $6500 and $7500 for 9 months.

This is actually the slow season for employment in mathematics. At the winter meetings there were close to 300 openings but only about 60 applicants, and there is no reason to expect any change in the balance at the 1961 winter meetings, which will be held in Washington, D.C., 24–27 January.

J. Sutherland Frame, Michigan State mathematics professor who started the employment register in 1953 and headed it for 5 years, said that it has been estimated that by 1963 the United States will need as many as 10,000 Ph.D. mathematicians for computer work alone. He pointed out that the country has only 5000 now and can expect to graduate only about 1000 more by 1963. Although the number of students majoring in mathematics is increasing, this is adding to the demand for mathematicians by universities.

Radiation Safety Experts Needed

Leroy E. Burney warned of a similar crisis in the supply of specialists in radiation safety when he reported, on 25 August, that by 1970 the nation will need at least 4000 more physicians, engineers, and physicists with extensive training in radiological health and protection. To meet this need, he said, colleges and universities should be admitting at least 600 candidates annually for specialized training. Only about 200 are currently getting such training each year.

AEC–NASA Nuclear Propulsion Office Established

The Atomic Energy Commission and the National Aeronautics and Space Administration have established a joint AEC–NASA Nuclear Propulsion Office to consolidate the work which has been carried out in each agency to develop nuclear energy for space missions. Harold B. Finger, chief of nuclear propulsion for NASA, is manager of the joint office, and Milton Klein, who has been assistant manager for technical operations of the AEC's Chicago Operations Office, is deputy manager. The staff, which is being drawn from both AEC and NASA, will work at AEC headquarters in Germantown, Md.

The Nuclear Propulsion Office will integrate the Project Rover nuclear-powered rocket development programs, which heretofore have been carried out by the AEC through the Aircraft Reactors Branch of its Division of Reactor Development and by NASA through its nuclear propulsion organization in the Office of Launch Vehicles. In accordance with the statutes for both agencies, AEC will have primary responsibility in this program for the development of all reactors and their components, including those for flight missions specified by NASA; NASA will have primary responsibility for research and development of nonnuclear components and integration of the nuclear components in engines and vehicles of rocket systems.

The Rover program was initiated in 1955 by the AEC and the Air Force. When NASA was established in 1958, Air Force responsibility was transferred to NASA.

Development of the reactor system is being carried out by the Los Alamos Scientific Laboratory, operated for the AEC by the University of California. Tests of two reactors, Kiwi-A and Kiwi-A Prime, were conducted at the AEC's Nevada Test Site in July of 1959 and July of 1960, respectively. A third reactor, Kiwi-A-3, is scheduled to be tested later this year.

Eight Scientists Die in Fire at Soviet Antarctic Base

Eight scientists died last month in a tragic fire at the U.S.S.R.'s principal research station in Antarctica—Mirny, on the Indian Ocean at Wilkes Land—according to a delayed report received by the National Science Foundation. The men lost—six Russians, a Czech, and a German—were identified as O. G. Krichak, chief of the aerological-meteorological section at Mirny; Visamushkov, aerologist; A. L. Dergach, meteorologist; I. A. Popov, aerologist; A. M. Belilikov, aerographer; A. Z. Smirnov, aerologist; and A. Kostka and C. Popp, both meteorologists. Gilbert Dewart of California Institute of Technology, who is at the base to work on a cooperative research program, was reported uninjured.

Mirny was opened in 1956 in preparation for the International Geophysical Year of 1957–58, but it was established as a permanent station. A group of American IGY scientists who visited Mirny in 1958 described its 18 prefabricated buildings—now increased to 40 or more—as sturdy and "more homey" than those at any U.S. polar base. They also commented that Soviet meteorological equipment was as efficient as that of the U.S. It is the meteorology building that was destroyed.

About 100 scientists and technicians will spend the next antarctic winter at Mirny, where it is now spring and time for the annual airlift of men and supplies to begin. The Soviet Union has two other winter stations in Antarctica, each staffed by about ten men, and in addition there is one small, two-man auxiliary camp.

This year approximately 195 men will winter at the U.S. bases in Antarctica; most of them will be at the main station in McMurdo, some 1460 miles from Mirny.

Radioactivity of Milk Tested in Almost Every State

The Public Health Service has announced that since last March it has increased from 10 to 59 the number of sampling stations for measuring radioactivity in milk. Coverage is now almost nationwide, with at least one sampling station in each of 47 states and the District of Columbia. Last month the network was extended to Puerto Rico, and it is expected that all 50 states will be included in the near future.

Previously, all laboratory work was done at the PHS Sanitary Engineering Center in Cincinnati, Ohio. Within the past 8 months two new regional laboratories for radiological analyses have been opened—one at Las Vegas, Nev., and one at Montgomery, Ala. The Montgomery facility processes samples from 30 states east of the Mississippi, and the Las Vegas laboratory, from states west of the Mississippi. For the present, the two new laboratories are testing only for strontium-90 and cesium-137. Until these laboratories are equipped to test for other radioactive elements, the laboratory at Cincinnati will continue to analyze samples from the ten older stations for iodine-131, strontium-89, and barium-140.

Results of the milk tests are tabulated and published in a monthly technical journal, *Radiological Health Data*, published by the Public Health Service. The results of the first analyses made on samples received from the expanded network appear in the September issue of the journal.

Data published in July by the Public Health Service showed that average measurements of strontium-90 in milk, in micromicrocuries per liter, during the period February 1959 through January 1960 ranged from 3.4 for Overton, Nev., to 22.4 for St. Louis, Mo. These averages were well within the level of 33 micromicrocuries per liter (or kilogram) for water, milk, and foods that is recommended as a guideline by the National Committee on Radiation Protection and the International Commission on Radiation Protection. This level has been adopted as a radioactivity concentration guide by the Department of Health, Education, and Welfare, pending completion of studies by the Federal Radiation Council, an advisory body established last year by President Eisenhower.

Grants, Fellowships, and Awards

Marshall scholarships. Twenty-four Marshall scholarships at British universities are offered annually by the British Government to United States graduate students. The awards, which last year were increased in number from 12 to the present 24, are an expression of the United Kingdom's gratitude for the post-war program for European recovery.

The awards are made to students of either sex, who must be citizens of the United States. Candidates must be under 26 years of age on 1 October in the year in which the award will be taken up, but in exceptional circumstances candidates up to the age of 28 may be considered. Candidates must be graduates of a degree-granting college or university of the United States, and they should be prepared to spend a reasonable proportion of their vacation time in the United Kingdom.

The scholarships are tenable at any university in the United Kingdom. Every effort is made to place a scholar at the university of his first choice, when this choice is in keeping with his degree program. The awards are made for 2 years but may be extended for a third. Marshall scholars are required to take a degree at their British university.

A Marshall scholar receives £550 a year and approved tuition fees. There are also small allowances for books. A married man's scholarship may be increased by £220 a year, under certain circumstances. Transportation between the scholar's home in the United States and his university in the United Kingdom is included.

For purposes of selection, the United States is divided into five regions. Applications for awards in the current program must be in the hands of the appropriate regional committee *by 31 October*. The committee addresses follow: North Eastern Region—British Consulate-General, Room 2610, John Hancock Building, Boston 16, Mass.; Mid-Eastern Region—British Consulate-General, 99 Park Ave., New York 16, N.Y.; Southern Region—British Consulate-General, 403 International Trade Mart, New Orleans 12, La.; Mid-Western Region—British Consulate-General, 720 N. Michigan Ave., Chicago 11, Ill.; Pacific Region—British Consulate-General, 2516 Pacific Ave., San Francisco 15, Calif.

Overseas teaching. The U.S. Office of Education's new publication, *Teacher Exchange Opportunities 1961–1962*, gives 15 October as the deadline for filing applications for employment overseas in 55 countries. About 400 teaching positions abroad will be available under the United States International Educational Exchange Program. Positions will be open in American-sponsored elementary and secondary schools, as well as in schools of the participating countries. For information, write to Teacher Exchange Section, U.S. Office of Education, Department of Health, Education, and Welfare, Washington 25, D.C.

Scandinavian research. Opportunities for specialized postdoctoral research and training for a 1-year period in Norway, Sweden, and Denmark are now available to five United States scientists under the terms of a $15,125 grant made by the National Science Foundation to the Scandinavian Council for Applied Research. Candidates may apply for awards in the following fields: acoustics, corrosion, chemical engineering, automation, microbiology, biotechnology, mass spectrometry, speech transmission, and calorimetry.

United States participation in the so-called "Growing Points" program was made possible when the National Science Foundation joined in supporting sponsorship of the program by the Scandinavian Council for Applied Research and the Organization for European Economic Cooperation. The foundation grant will provide about $825 for institutional costs, $1500 for stipends, and $700 for travel for each United States participant. Selection of United States participants will be made by the Scandinavian Council for Applied Research. Applicants should direct inquiries to its office at Gaustadalleen 30, Blindern, Norway.

News Briefs

Copenhagen isotope conference. A Conference on the Use of Radioisotopes in the Physical Sciences and Industry, now being held in Copenhagen, will end on 17 September. Approximately 600 scientists, from some 40 countries and several international organizations, are participating in the meeting, which is jointly sponsored by the International Atomic Energy Agency and the United Nations Educational, Scientific and Cultural Organization.

The largest number of contributions are from American scientists, who will present 40 papers. Among other contributions are 29 papers from the United Kingdom and 20 from the Soviet Union. Abstracts may be obtained from IAEA Division of Public Information, Vienna 1, Austria.

* * *

Basic science in France. A symposium on Basic Science in France and the United States will take place 17–19 October at New York University. The visitors from abroad will include J. C. Pebay-Peroula, laboratory director, Ecole Normale Supérieure, Paris; L. Escande, director, Ecole Nationale Supérieure, Toulouse; L. Neel, director, Metal Physics Laboratory,

Fourier Institute, Grenoble; Jean Denisse, chief astronomer, Meudon Observatory, Meudon; G. Millot, University of Strasbourg; and Pierre Pigagniol, science adviser to the French Government.

* * *

Research in burns. Civilian and military physicians and research biologists from 17 nations will gather at the National Naval Medical Center, Bethesda, Md., 19–22 September for the first International Congress on Research in Burns. Some 56 research and clinical reports will be presented on such subjects as tissue transplantation, electrolyte balance and metabolism, and prevention of infection. Half of the papers will be by foreign scientists. Curtis P. Artz of the University of Mississippi Medical Center, Jackson, is coordinator of the program. Sponsoring agencies include the medical departments of the Army, Navy, and Air Force, the Public Health Service, and the American Institute of Biological Sciences.

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Tobacco research. Research grants totaling more than $523,000 have been made to 40 scientists in 1960 by the Tobacco Industry Research Committee. Twenty of the grants are new, and 20 are for continuation of work under way. More than 100 independent scientists have received support since mid-1954. The committee has so far appropriated $3.7 million for its continuing research program. All grants are made by the Scientific Advisory Board, composed of nine physicians, scientists, and educators, who retain their institutional affiliations. Chairman of the board is Kenneth M. Lynch, chancellor of the Medical College of South Carolina, Charleston.

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Register of scientists. The National Science Foundation is requesting the cooperation of scientists in filling out the questionnaires mailed in recent months in order to compile a comprehensive register of the nation's scientific talent. This will be a revision of the register compiled in 1956–1958. Its purpose is to make available to government agencies information that will enable them to locate men with special qualifications for doing work on projects that may be undertaken in the national interest. To date, about 175,000 questionnaires have been returned, and preliminary processing and compilation have begun. The NSF hopes to receive responses from at least another 75,000 scientists.

Scientists in the News

Wolfhard Weidel, director at the Max Planck Institute for Biology and professor in the University of Tübingen, has been appointed visiting professor of virology for 1960–61 at the University of California, Berkeley. He replaces **Gunther S. Stent**, who will spend a year's sabbatical leave at the universities of Kyoto and Cambridge.

Rudolf T. van Dam of Amsterdam University, the Netherlands, will be visiting professor of physiology for 1960–61 at the State University of New York Downstate Medical Center in Brooklyn. He succeeds **David R. Curtis** of the Australian National University, who has been visiting professor since 1 September 1959.

Gerhard Schilling, former chief of the Lunar and Planetary Sciences Programs at the National Aeronautics and Space Administration, recently joined the staff of the Rand Corporation, Santa Monica, Calif. He is a member of the Planetary Sciences Group in Rand's Engineering Division and is conducting research on problems of space exploration.

Herman M. Kalckar, professor of biology at Johns Hopkins University, has recently returned from the U.S.S.R. He is the first general-biologist exchange visitor to travel in the Soviet Union as a member of the U.S. National Academy of Sciences. He was a guest of the Soviet Academy of Sciences.

Charles E. Kellogg, assistant administrator for soil survey with the Soil Conservation Service, U.S. Department of Agriculture, received an honorary degree of doctor of science from the Institut Agronomique de l'Etat at Gembloux, Belgium, on 29 July on the occasion of the 100th anniversary of the founding of the institute.

Carl R. Brewer, formerly chief of the Research Division, U.S. Army Chemical Corps Research and Development Command, Washington, D.C., has been appointed chief of the Research Grants Branch, Division of General Medical Sciences, National Institutes of Health.

Sidney L. Simon has been appointed chief engineer, Missile Electronics and Controls Division, RCA Defense Electronic Products, Burlington, Mass. A member of the RCA staff since 1958, Simon succeeds **Robert C. Seamans, Jr.**, who has accepted a post with the National Aeronautics and Space Administration.

Richard Trumbull, head of the Physiological Psychology Branch at the Office of Naval Research since November 1953, has been awarded the Navy Superior Civilian Service Award, the second highest honorary Navy civilian award. He received the award for his part in the direction and development of an outstanding Navy research program in physiological psychology that is recognized throughout the United States, Canada, and Europe.

Perry Byerly, professor of seismology at the University of California, Berkeley, was elected to a 3-year term as president of the Association of Seismology and Physics of the Interior of the Earth during the general assembly of the International Union of Geodesy and Geophysics that was held recently in Helsinki, Finland. The association is a member of the International Union.

Nathan B. Eddy, research pharmacologist at the National Institutes of Health for the past 21 years, has retired from the U.S. Public Health Service. Since 1951 he has been chief of the section on analgesics in the Laboratory of Chemistry, National Institute of Arthritis and Metabolic Diseases. Eddy is executive secretary and chairman of the Committee on Drug Addiction and Narcotics of the National Research Council and a member of the Expert Committee on Addiction-Producing Drugs of the World Health Organization.

Recently, with Everette L. May, he conducted research that resulted in the synthesis of phenazocine (NIH 7519), a new analgesic which is a more effective painkiller than morphine but has fewer side effects and is less likely to produce addiction. He is coauthor of *Pharmacology of Opium Alkaloids* and *Studies in Drug Addiction* and has written more than 140 papers.

Eddy was assistant, then associate, professor of pharmacology and physiology at the University of Alberta, Canada, until 1930, when he became research professor of pharmacology at the University of Michigan. He joined NIH in 1939. He will continue his activities on scientific committees and panels of experts and will serve as a consultant to NIH.

The Washington University School of Medicine has announced the appointment of two visiting professors from England: **J. Harold Burn**, pharmacologist, and **Robert H. Heptinstall**, pathologist. Burn, who was visiting professor at Washington University for 6 months in 1959–60, was professor and head of the department of pharmacology at Oxford University from 1957 to 1959 and now holds the rank of professor emeritus. Heptinstall is a member of the department of pathology at St. Mary's Hospital Medical School, London.

Clinton R. Hanna, associate director of the Westinghouse Research Laboratories, Pittsburgh, and a specialist in electromechanical research, has retired after 38 years of service. He joined the laboratories as a research engineer upon his graduation from Purdue University in 1922.

Hanna has gained international recognition for his research in electrical control devices to regulate the speed and position of moving objects—devices such as automatic pilots for aircraft, stabilizers for shipboard radar antennas, vehicle stabilizers, elevator controls, and the Vibragyro, a type of gyroscope having no rotating parts. Another of Hanna's inventions is the Silverstat, an automatic voltage control device for electric generators, motors, and other electrical equipment. He holds more than 100 patents. Hanna will continue his service to Westinghouse as a consultant.

Sidney R. Galler, head of the Biology Branch of the Office of Naval Research in Washington, D.C., has received the Navy's Superior Accomplishment Award for developing a research program in biology.

The Air Force's Geophysics Research Directorate, Bedford, Mass., has announced the appointment of **Arnold Court** as chief of the applied climatology branch of its Meteorological Development Laboratory. Court served previously as a research meteorologist with the U.S. Forest Service in Berkeley, Calif., and as a lecturer at the University of California.

Hans Molitor, director of the Merck Institute for Therapeutic Research from its establishment in 1933 until 1956, retired on 1 September from his current position as director of scientific relations of the Merck Sharp and Dohme Research Laboratories Division, Rahway, N.J. Molitor, born and educated in Czechoslovakia, joined Merck from the University of Vienna, where he had earned his M.D. degree and where he was subsequently associate professor of pharmacology and therapeutics.

When Molitor first arrived at Rahway, the Merck Institute consisted of three small laboratory rooms and an office. His two-man staff had just been graduated from high school. Today, the institute has a staff of 300 scientists and technicians and extensive facilities that include a 200-acre experimental farm. Accomplishments include contributions to the development of a number of vitamins, steroid hormones, antibiotics, diuretics, and antihypertensive drugs.

D. Jerome Fisher, professor of geology at the University of Chicago, was elected to a 4-year term as president of the International Mineralogical Association during its recent meeting in Copenhagen, Denmark.

Charles E. Crompton has been named director of the advanced development section in the Isotopic Power Department of the Martin Company's Nuclear Division, Baltimore. Formerly he was associate technical director of the National Lead Company of Ohio, and before that, deputy director of the Atomic Energy Commission's Isotopes Division.

B. Theodore Cole, research participant in the Cell Physiology Section, Biology Division, Oak Ridge National Laboratory, has been appointed associate professor of biology at the University of South Carolina.

Carl C. Pfeiffer, director of the Division of Basic Health Sciences, Emory University, has resigned to do full-time research in mental health at the New Jersey Bureau of Research in Psychiatry and Neurology, Princeton, N.J., where he will be head of the section on psychopharmacology.

Merlin D. Peterson, formerly director of Industrial Reactor Laboratories, Inc., Plainsboro, N.J., has resigned that position to accept an appointment as deputy associate laboratory director for education at Argonne National Laboratory, Argonne, Ill. He will assist in the administration of Argonne's extensive program of cooperation with universities and colleges throughout the world.

Maurice E. Odoroff, formerly chief of the evaluation and reports branch and the research grants branch of the Division of Hospitals and Medical Facilities, U.S. Public Health Service, has been appointed assistant to the chief, Division of General Medical Sciences, National Institutes of Health. Odoroff's work will be concerned primarily with the statistical reporting and analytical activities of the division's operations.

Recent Deaths

Alfred J. Brown, Council Bluffs, Ia.; 81; emeritus professor of surgery at the University of Nebraska College of Medicine; well-known as a collector of medical incunabula and as a bookplate engraver; 22 Aug.

Herman N. Bundesen, Chicago, Ill.; 78; president of the Chicago Board of Health since 1933 and an authority on baby care; wrote a syndicated column on health that appeared in more than 500 newspapers; 15 Aug.

Harry K. Ihrig, Milwaukee, Wis.; 62; vice president for research at the Allis-Chalmers Manufacturing Company and research professor of biophysics at Marquette University; 22 Aug.

Joseph W. Jailer, Scarsdale, N.Y.; 46; associate professor of clinical medicine at Columbia University's College of Physicians and Surgeons; conducted research in endocrinology; 23 Aug.

Arnold S. Levine, Philadelphia, Pa.; 48; chief of neurology at Einstein Medical Center, Southern Division; assistant professor of neurology at Jefferson Medical College; and president of the medical staff at Kensington Hospital; 23 Aug.

T. M. B. Payne, Winnipeg, Canada; 42; professor and head of the department of microbiology at the University of Manitoba; 12 Aug.

Martha R. Smith, West Falmouth, Mass.; 65; retired dean of the Boston University School of Nursing; 21 Aug.

Samuel A. Stouffer, Cambridge, Mass.; 60; director of the Laboratory of Social Relations at Harvard University; noted for his research on many aspects of public opinion; his writings include *The American Soldier* (of which he was the principal author) and *Communism, Conformity and Civil Liberties*; late August.

Arthur E. Wood, Hamilton, N.Y.; 82; retired associate professor of chemistry at Colgate University; specialized in physical chemistry, on which he had written several books; 21 Aug.

Book Reviews

Philosophical Anthropology and Practical Politics. F. S. C. Northrop. Macmillan, New York, 1960. x + 384 pp. $6.50.

Among the many arguments which Northrop presents in this book, the following are the most recurrent:

1) The "practical" power-politicians of the United States and its allies and of the Soviet Union and the Peoples' Republic of China are, in fact, dangerously impractical in their fundamental presupposition about international affairs.

2) On both sides, this presupposition (put, very simply, that only might can make right) derives ultimately from the naive realism of Aristotelian physics which holds that the only true entities are those which can be immediately intuited by the physical senses. On the "Western" side, this notion was translated from physics to politics most influentially by Thomas Hobbes, with his idea that justice can derive only from a sovereign and that, therefore, sovereignty per se is justice. Such a view applied today holds, among other things, that since there is no international sovereign, there is no international justice or law in any real sense. As one illustration of this point of view, Northrop several times scathingly (and welcomely in my opinion) cites Dean Acheson's contemptuous dismissal of President Eisenhower's invocation of international law at the time of the Suez crisis. On the "Eastern" side, this presupposition derives most immediately, of course, from the dialectical materialism of Marx in which social conflict is as axiomatic as it was in Hobbe's formulation.

3) This presupposition is impractical in the sense that it commits the power-politicians on both sides, wittingly or unwittingly, to playing a game in which, as Northrop rather nicely puts it, "clubs become trumps," but in which the "clubs" are now thermonuclear weapons whose use would annihilate mankind in its present form. Those who are unwittingly committed are as dangerous as the others since they cannot analyze and therefore reorient their courses of action. One consequence of this has been that United States policy vis-à-vis the Communist bloc has been defensively "unimaginative" and has taken the initiative only in the form of Hobbesian military and economic aid power plays. The latter have endeared the United States to no one, as Northrop discusses in a number of instances at some length, although he acknowledges that intervention by the United States in Korea was a dire necessity.

4) The confusion of the power politicians, and others, in the democratic countries is confounded by the fact that they inherit, in addition to the Aristotelian-Hobbesian-concepts-by-immediate-sense-intuition tradition, another tradition which is different from the Aristotelian-Hobbesian one not only in content but in its fundamental epistemology as well. This other tradition is the Lockean-Jeffersonian political philosophy, epitomized in the Declaration of Independence and the Bill of Rights, which ultimately derives from the law of contract, as opposed to the law of status (elucidated by Sir Henry Maine), which was developed by the Roman Stoic statesmen. They, in turn, derived the law of contract from the epistemology of Plato and the non-Aristotelian Greek mathematicians. This epistemology comprises imageless concepts by postulation rather than concepts derived from immediate sensory intuition.

5) That concepts by postulation are as pragmatically "real," "hard-headed," and "down-to-earth" as concepts derived from immediate sensory intuition is asserted by Northrop essentially in two ways. First, he devotes most of chapter 3 to a rather technical discussion of certain findings of neurophysiology showing that both types of concept are products of reverberating neural circuits in the cortex. Both types of concept can and do become "trapped" in neural circuits, or, in lay terms, become fixed and accepted notions in the mind. Second, he emphasizes that the most formidable club of the naively realistic "practical" politicians and military men—the atomic bomb—is a product of concepts by postulation of the highest order. Einstein's mathematics, ultimately also derived from the non-Aristotelian postulational mathematics of the Greeks, is revealed as an epistemological kinsman of the Roman Stoic-Lockean-Jeffersonian law of contract, so that if the one has proved to be eminently "practical," the other must be also.

6) The foreign policy of the United States, which began in the Lockean-Jeffersonian tradition, has in recent decades been formulated by the Hobbesian mentalities of corporation lawyers and generals, while during the same period the reverse tendency has been evident in British foreign policy (the Suez affair being a notable exception to both tendencies), with consequent misunderstandings between the two allies. It is primarily due to the lack of understanding among the American people at large and their practical politicians of the epistemological bases of their primary normative patterns that Americans are unable to define their cherished Lockean-Jeffersonian principles clearly to themselves or to anyone else in the world. It is also due to this lack of understanding that United States foreign policy fluctuates blindly and unpredictably between these two traditions. Clearly needed is an intensive philosophical education of the American people and most certainly of their diplomatic politicians.

7) Meanwhile, the various new nations in Africa and Asia, particularly, are writing constitutions (normative political cultural patterns) which incorporate Lockean-Jeffersonian law of contract principles. However, their leaders face, but generally do not see clearly, the difficulties of accommodating these principles to the "living law" (that is, the indigenous cultural patterns) of their people. These systems of "living law," though often very different from each other in detail, have in common the fact that they are based on the law of status. If these leaders are to succeed in establishing new nations whose domestic laws and international relations are based on the law of contract, they cannot merely impose the latter on the indigenous patterns. Rather, the indigenous patterns must be analyzed in terms of their basic assumptions, and ways must be found to

synthesize with the law of contract those parts of the "living law" which are not absolutely incompatible with it. As a model of such analysis, Northrop cites Kluckhohn's study of the basic postulates of Navaho culture, and it is in this general connection that his "philosophical *anthropology*"—a kind of cross-cultural epistemology—comes to the fore. Philosophical anthropologists are needed, therefore, not only in the councils of these countries but also in our State Department if the United States is to be able effectively to help the new nations reach their goals. It should be noted that Northrop is dealing here with a particularly subtle aspect of the whole issue of congruities and incongruities in cultural contact, and anthropologists, many of whom have dealt with the matter rather fuzzily, may very well find his approach to it a stimulating one.

The foregoing is an attempt to synthesize what seem to me to be the issues of greatest concern to Northrop in his book. It is not, however, the author's over-all summary, for in fact there is none. This, in a book which is so discursive as to be worthy of Toynbee unabridged, is an unfortunate omission. Opening with a statement related largely to item 7 above, Northrop then introduces his other points and proceeds in the rest of the book to put them through a sort of leapfrog exercise in which all of them reappear more than once. While this may seem repetitious to some readers, it serves a useful purpose, for Northrop's ideas generally need to be restated in different contexts in order that they may be fully grasped. Thus, there are some partial summaries and syntheses.

One suspects that this organization is a result less of deliberate planning than of the nature of the component parts of the book. There are 19 chapters, arranged in three parts, of which seven are reprints of articles which were published individually in the 1950's. These are concentrated in part 2; the composition of parts 1 and 3 would, generally speaking, appear to have been later. While cross references to chapters have been inserted, there is a disconcerting patchwork quality to the whole.

Part 1 consists largely of formal philosophical and logical expositions and proofs of the author's major points. Most of this part consists of some truly formidable prose, and one can fairly derive some wry amusement from the fact that it might well be a literal translation of that "cumbersome and wordy German philosophical prose" which Northrop, in part 3, disapprovingly associates with Immanuel Kant, saying that he should have used symbolic logic instead. If Northrop wishes his part 1 to be fully appreciated by readers who have not been trained to cope with formal philosophy, he will need to revise it someday. As matters stand, however, such readers will not go too far astray if they commence their reading with the beginning of part 2; those chapters are a series of applications of the author's ideas concerning such areas as political evolution in various parts of Latin America, the ideological failure of technical assistance in Ceylon, and the philosophical-anthropological reasons for the rapid transformations in Communist China, to name but three. From the point of view of an anthropological reader such as I am, part 2 is the best part of the book, for in it the author not only states his basic ideas in simpler terms than in part 1, but he also sets them in specific cultural contexts. There is good anthropology per se in part 2, and the reader may make excursions into part 1, as Northrop suggests at several points, for rigorous philosophical support, if he so chooses.

Part 3 has but three chapters, the first being a reprint which includes an eloquent statement of the pejorative image of itself which the United States has exported. The remainder concerns itself primarily with the necessity, and with suggestions of the means, for working toward the cultural syntheses which have been indicated earlier. The possibility that the democratic and Communist bloc nations may achieve, through philosophical-anthropological diplomacy, a mutual rejection of the Aristotelian-Hobbesian presupposition is discussed.

It is easy to find fault with a book which takes the whole contemporary world, several disparate courses of history, and the findings of half a dozen academic disciplines as its province and attempts a systematization of such knowledge. It can hardly be easy, however, to write such a book even when many years of reflection have preceded its composition. And so, while we may question whether all the social concepts which are subsidiary to the law of contract are actually so imageless as Northrop seems to suppose, we can also recognize with appreciation his point that concepts, of whatever epistemological derivation, are behaviorally significant. We can also appreciate that while Northrop proposes an epistemological dichotomy, he does not force it into becoming a generally cultural dichotomy. For instance, he recognizes that the law of status cannot be neatly and exclusively associated with primitive or nonindustrial cultures, nor is it "ancient" in contrast to any supposed modernity of the law of contract. Though he indulges in some irritating phraseologies of his own, he assiduously avoids the trite and misleading contrast between "East" and "West," and so these expressions, used for convenience only, are put in quotes in this review. While his personal predilection seems to be for concepts by postulation and the law of contract, he does not disown the contribution of concepts by immediate sensory intuition, particularly with respect to the esthetics of the Far East—this, of course, being a legacy from his earlier book, *The Meeting of East and West*.

Philosophical Anthropology and Practical Politics communicates a number of valuable insights to scholars and to "practical" laymen. It is unfortunate that it often says these things in a more abstruse manner than would seem to be necessary. However, the fact that Northrop forthrightly climbs out onto a number of limbs commands our respect, and the probability that many readers will attempt to cut off or severely to prune those limbs bespeaks the book's importance.

JOHN GULICK

Department of Sociology and Anthropology, University of North Carolina

A Collection of Mathematical Problems. S. M. Ulam. Interscience, New York, 1960. xiii + 150 pp. $5.

The unsolved problems in mathematics can be divided broadly into two classes. There are problems such as appear in number theory which are very easy to formulate and which require almost no mathematical background to understand. These "easy" problems usually turn out to be very difficult to solve. On the other hand, there are problems like those in this collection, which require the reader to have a good background in the subject matter in order to understand what they are about. While such problems are also difficult to solve, their difficulties are relatively easier to surmount. Thus,

several problems included here were solved in the interval between the writing and the publishing of the work.

The problems in this book come from various branches of mathematics—for example, set theory, algebra, topology, analysis, and mathematical physics. The presentation of the problems varies. In some cases there is a rather lengthy discussion of the problem and its motivation, with partial results and implications resulting from its solution. In other cases there is only a dry listing of problems and conjectures. And sometimes no particular problem is discussed; instead an entire area of research is suggested. Thus, the chapter on computing machines as a heuristic aid gives the author's ideas on the subject of man-machine cooperation in solving some outstanding problems in mathematics and mathematical physics.

Although the range of topics is wide, there seem to be several unifying concepts, the principal one being that of transformation. There are also several scattered problems whose formulation is simple. However, the overwhelming majority of the problems are difficult both to formulate and to solve; they should provide Ph.D. advisers with sufficient material to offer to their aspiring young mathematicians.

PHILIP RABINOWITZ
National Bureau of Standards, Washington, D.C.

Search for the Past. An introduction to paleontology. James R. Beerbower. Prentice-Hall, Englewood Cliffs, N.J., 1960. xiii + 562 pp. Illus. $7.50.
Invertebrate Paleontology. W. H. Easton. Harper, New York, 1960. xii + 701 pp. Illus. $10.

At a time marked by an ever increasing volume of textbooks in geology and related sciences, *Search for the Past* is one of few that is really new both in content and presentation. Unlike the standard paleontology texts, this book does not specially emphasize identification and classification but is, instead, a series of broad discussions dealing with basic zoologic and paleontologic principles. Although intended as an introductory college text, the book has a fresh, readable style that should make it pleasant, informative reading for amateur and professional scientists alike. The text is direct, nondogmatic, and last-minute modern. The chapter and topic headings represent high good humor and add zest to the main theme.

Approximately the first third of the volume is devoted to the direct development of fundamental principles, problems, and methods of modern paleontologic research. Such topics as "The shapes of animals," "The diversity of species," "Patterns of evolution," "Fossils and stratigraphy" are well chosen and carefully developed. Beerbower's chapter, "The species," is notable in that it approaches the subject from the viewpoint of population and covers such subjects as the genetics, morphology, and ecology of populations—subjects not ordinarily found in invertebrate paleontology texts. In keeping with his portrayal of paleontology as a developing science, the author includes examples of statistical and model techniques that are only now receiving widespread application in the profession. Unfortunately, in presenting such statistical methods, Beerbower is not at his best.

The latter two-thirds of the book, chapters 8 through 21, are devoted to the major fossil groups, including vertebrates, with special emphasis on their living relatives. The morphology, adaptation, evolutional history, and paleoecology of each are presented in brief, general discussions. These do not attempt to cover every group in a comprehensive manner but are used to emphasize and illustrate principles of evolution and adaptation. Chapters are interrelated in such a manner that they unfold a story of progressive evolution of the animal groups. A brief glossary of morphologic terms and a simplified classification table are included for each group. Only the most important references are included in the chapter bibliographies, but annotation increases their usefulness.

As an author's first book, *Search for the Past* has relatively few faults. The most critical is lack of adequate illustration. The drawings are not well planned and are of an entirely different order of competence than the text. Many are cluttered and difficult to interpret; few are attractive. The tables and their explanations have not been positioned well by the editors, and some tables do not have adequate explanations. Nevertheless, the book is a lively, readable introduction to basic principles, with emphasis on biology rather than stratigraphy, and well suited to fill the long-standing need for teaching paleontologic principles. The author, a young college teacher, is to be congratulated for recognizing and meeting the challenge. Such an auspicious beginning bodes well for future editions of this well-planned and teachable text.

William Easton's *Invertebrate Paleontology*, like Beerbower's *Search for the Past*, represents an author's first effort in the textbook field. However, unlike Beerbower's text, which is fundamentally a book on principles, *Invertebrate Paleontology* is devoted mainly to morphology and classification. As such, it is intended for use in intermediate college courses where emphasis is on training the student to recognize the principal fossil groups and to collect and prepare specimens intelligently for identification and evaluation by specialists.

Even though these goals are modest, it is disappointing to find a 1960 textbook that devotes only a single chapter to general discussions of such fundamental subjects as classification, nomenclature, methods in paleontology, evolution, correlation, and environment. Some of these deficiencies are compensated for in subsequent chapters by discussions which illustrate topics of special significance, but the very incomplete table of contents precludes the discovery of these topics except by thumbing through the text.

With the exception of the first chapter, the volume is devoted entirely to a systematic series of discussions of animal groups arranged in biological order. Protozoans, sponges, brachiopods, gastropods, and cephalopods are allotted one chapter each. Coelenterates, echinoderms, and arthropods receive two chapters each. The bryozoans and phoronids; worms and conodonts; and chitins, pelecypods, and scaphopods are covered in single chapters. Most of the animal discussions consist of three main parts: (i) consideration of soft- and hard-part morphology, (ii) discussion of classification, and (iii) summary of geologic distribution. The morphology and classification sections for each group are generally comprehensive and well illustrated. Classification, which occupies the major portion of each chapter, contains brief but commonly awkward descriptions of every major taxon. Short tabular keys to the classification of each group are exceedingly useful. The geologic summaries have been reduced to briefest terms, but they are accompanied by effective, simplified range charts.

Throughout the group discussions, several devices are used to make the

text more comprehensible. For example, uniform endings are applied to names of all taxa up through Order; nomenclatural terms such as *Genus, Genera, Families,* and *Subclass* are capitalized to indicate that they are being used in a formal sense; and use of stratigraphic terms is reduced to system names for the Paleozoic and Mesozoic and series names for the Cenozoic. In addition there is a series of study questions for students at the end of each chapter. The bibliographies are comprehensive.

In over-all aspect, Easton's text is authoritative, well organized, and beautifully illustrated. Nevertheless, the volume contains little that is original and much that has been better stated elsewhere. Furthermore, in his effort to reach the intermediate level, Easton has reduced his book to little more than a compendium of morphologic terminology and taxonomic categories. One has the feeling that the book is designed for mediocre students rather than as a challenge to those at the intermediate level.

CHARLES COLLINSON
Illinois State Geological Survey, Urbana, Illinois

Dynamic Programming and Markov Processes. Ronald A. Howard. Technology Press and Wiley, New York, 1960. viii + 136 pp. Illus. $5.75.

Although the material contained in this book is of some interest to operations researchers, it is difficult to see a justification for publishing it as a book rather than as a paper or a series of papers.

The first thing to remark is that, in spite of its title, the book is neither about dynamic programming nor about Markov processes. It is rather a treatment of a single model for decision-making which has the flavor of both topics, but it does not discuss either except as the topic reflects on the author's problem. The problem, briefly stated, is as follows: Suppose one's profits are governed by a finite state, discrete Markov process in which one has some degree of control over the transition probabilities (for example, by research and advertisement). Suppose further that the profit for a transition $i \rightarrow j$ is given by an array r_{ij}, which are known quantities. What is the optimal policy for the manipulation of transition probabilities in order to maximize profit? This same problem is discussed under different circumstances with essentially the same solution given for each case. Many illustrative examples are discussed; none of these are of particular interest since they consist merely of substituting numbers into the established formulas.

It has always seemed to me that writing a book implies an evaluation of the generality and the permanent interest of the material contained in it. On this basis and on the over-all thinness of the subject matter, I would call Howard's book premature and without perspective.

GEORGE WEISS
Institute for Fluid Dynamics and Applied Mathematics, University of Maryland

New Books

Biological and Medical Sciences

Abelson, D., and R. V. Brooks, Ed. *Quantitative Paper Chromatography of Steroids.* Cambridge Univ. Press, New York, 1960. 110 pp. $6. Proceedings of a symposium held in July 1958 to discuss problems in the application of paper chromatography to the quantitative estimation of steroids.

Abramson, Harold A., Ed. *The Use of LSD in Psychotherapy.* Josiah Macy, Jr. Foundation, New York, 1960. 304 pp. $5. Transactions of a conference on D-lysergic acid diethylamide (LSD-25); the conference was held 22–24 April at Princeton, N.J.

Alexander, Frank. *An Introduction to Veterinary Pharmacology.* Livingstone, Edinburgh, Scotland; Williams and Wilkins, Baltimore, Md., 1960. 187 pp. $4.75.

Andrews, R. D., Ed. *Transactions of the Society of Rheology.* vol. 3. Interscience, New York, 1960. 216 pp. $6.75.

Bourne, G. H. *The Structure and Function of Muscle.* vol. 1, *Structure.* Academic Press, New York, 1960. 488 pp. $14.

British National Formulary. Alternative edition, 1960. Based on a pharmacological classification. British Medical Assoc. and Pharmaceutical Soc. of Great Britain, London, 1960. 292 pp. $1.75.

Crampton, E. W., and L. E. Lloyd. *Fundamentals of Nutrition.* Freeman, San Francisco, 1960. 504 pp. $7.50.

Cumings, John N., Ed. *Modern Scientific Aspects of Neurology.* Arnold, London; Williams and Wilkins, Baltimore, Md., 1960. 365 pp. $13.

Dodson, Edward O. *Evolution.* Process and product. Reinhold, New York; Chapman and Hall, London, 1960 (revised text edition of *A Textbook of Evolution*). 368 pp. Text, $5.75; trade, $6.90.

Edsall, John T., Ed. *Amino Acids, Proteins and Cancer Biochemistry.* Academic Press, New York, 1960. 253 pp. $7. Contains the papers presented at the Jesse P. Greenstein Memorial Symposium held by the Division of Biological Chemistry of the American Chemical Society, 16 September 1959. The volume also contains a biographical article and a bibliography of Greenstein's writings.

Etter, Lewis. *Glossary of Words and Phrases Used in Radiology and Nuclear Medicine.* Thomas, Springfield, Ill., 1960. 218 pp. $8.50.

Garland, Joseph E. *An Experiment in Medicine.* The first 20 years of the Pratt Clinic and the New England Center Hospital of Boston. Riverside Press, Cambridge, Mass., 1960. 177 pp.

Glick, David, Ed. *Methods of Biochemical Analysis.* vol. 8. Interscience, New York, 1960. 409 pp. $10.

Harris, E. J. *Transport and Accumulation in Biological Systems.* Academic Press, New York; Butterworths, London, ed. 2, 1960. 290 pp. $9.

Hockenhull, D. J. D., Ed. *Progress in Industrial Microbiology.* vol. 2. Interscience, New York, 1960. 201 pp. $7.50.

Hockensmith, Roy D., Ed. *Water and Agriculture.* AAAS Symposium No. 62. AAAS, Washington, D.C., 1960. 206 pp. $5; prepaid order to members, $4.50. A symposium presented at the AAAS Washington meeting; 16 papers on the following topics: water for the future (covering the resources, legal aspects of water use, significance of small watershed programs, and water management and groundwater supplies in agriculture); water sources (factors that affect the water cycle, effects of weather modification on water supplies, the use of climatic data in guiding water management on the farm, and precipitation measuring and analysis as an aid to agriculture); water planning and use (relations between soil conservation practices and availability of water, increasing water yields by forest management, interdependence of upstream and downstream water management, views of water users on federal reclamation projects); water control (agricultural drainage, control of aquatic and bank vegetation and phreatophytes, suppressing evaporation from water surfaces, energy balance approach to evapo-transpiration from crops).

House, Earl Lawrence, and Ben Pansky. *A Functional Approach to Neuroanatomy.* McGraw-Hill, New York, 1960. 503 pp. $12.50.

Kisch, Bruno. *Electron Microscopy of the Cardiovascular System.* Translated from the original German text by Arnold I. Kisch. Thomas, Springfield, Ill., 1960. 192 pp. $7.50.

Kundu, B. C., K. C. Basak, and P. B. Sarcar. *Jute in India.* Indian Central Jute Committee, Calcutta, 1960. 411 pp. Rs. 30. This monograph deals with the botany, cultivation, diseases, and pests of jute; with its economic and marketing problems; and with the problems of jute manufacture and technology.

Machlis, Leonard, Ed. *Annual Review of Plant Physiology.* vol. 11. Annual Reviews, Palo Alto, Calif., 1960. 475 pp. $8.

Nowinski, Wiktor W., Ed. *Fundamental Aspects of Normal and Malignant Growth.* Elsevier, Amsterdam, Netherlands; Van Nostrand, Princeton, N.J., 1960. 1041 pp.

Reports

Carbon-14 Dating with the Liquid Scintillation Counter: Total Synthesis of the Benzene Solvent

Abstract. Samples are analyzed for natural radiocarbon content by a total synthesis of benzene from their organic constituents. The benzene is employed as the solvent in a liquid scintillation counter. The instrument used permits 15 grams of carbon to be counted with an efficiency of 40 percent and a background of 13 counts per minute.

The discovery of the method of radiocarbon dating by W. F. Libby and his associates in 1947 has been recognized as a very important event in many branches of science, especially archeology and geology. Analysis of organic materials for their C^{14} activity allowed determination of ages of many thousands of years. However, the radioactivities measured are fairly low, and elaborate procedures of sample preparation and counting must be followed in order to obtain significant results (*1*). Libby's original method of producing samples to be counted as solid elemental carbon was improved upon by the introduction of the organic material in the form of a gas directly into a proportional region counting tube. This type of procedure has allowed the sensitivity of the method to be pushed to 50,000 years (*2*).

More recently, the introduction of the liquid scintillation counter has led to the development of several dating methods in which preparation of liquid materials from the organic samples to be dated are utilized (*3*). Liquid scintillation counting has the advantage of using liquid samples which are much easier to handle and purify than the gaseous or solid materials that are necessary in the other counting arrangements. Also, it is possible to submit more carbon to analysis as compact liquids than as the much less dense gases. The disadvantages of present radiocarbon dating by liquid scintillation counting methods are that the preparation of the samples is more complicated and less efficient than the gas methods and that it has not been possible to synthesize the solvent completely, in reasonable yields, from the carbons in the material to be analyzed. The procedures now described in the literature require either dilution of the ordinary scintillator solvent system with another miscible liquid that has been prepared from the specimen to be dated or modification of existing organic compounds with carbon dioxide whose natural radiocarbon content is to be analyzed. Both of these conditions lessen the effectiveness of the basic method.

A liquid scintillation procedure has been worked out which improves the usefulness of radiocarbon dating. The method provides a solvent which contains 92 percent carbon, all of which is obtained from the sample to be dated. The solvent is benzene and the steps of the total synthesis employed in the method are listed below:

$$\text{Organic material} + O_2 \rightarrow CO_2 \quad (1)$$

$$CO_2 + 2NH_4OH \rightarrow (NH_4)_2CO_3 + H_2O \quad (2)$$

$$(NH_4)_2CO_3 + BaCl_2 \rightarrow BaCO_3 + 2NH_4Cl \quad (3)$$

$$2BaCO_3 + 5Mg \rightarrow BaC_2 + BaO + 5MgO \quad (4)$$

$$BaC_2 + 2H_2O \rightarrow C_2H_2 + Ba(OH)_2 \quad (5)$$

$$3C_2H_2 \rightarrow C_6H_6 \text{ (at 650°C)} \quad (6)$$

Steps 1 through 5 are a standard procedure for the production of acetylene (*4*). Step 4 was changed in that the reaction is carried out in a helium atmosphere rather than in a vacuum. The violence of the exothermic reaction varied so widely with the batch of powdered magnesium used that it was impossible to assure that the closures on the stainless steel tube would not blow out during the reaction. The procedure actually followed was to first evacuate the tube with the mixed powder, then introduce helium gas and continue it flowing through, and finally to ignite the open end with a magnesium ribbon fuse. In step 6 the acetylene was circulated repeatedly through a Vycor tube heated to 650°C, and the pyrolysis products were trapped out by a trap cooled by dry ice and located in the circuit. Most of the liquid collected in the trap is benzene. After all the acetylene has been subjected to the heated tube the organic liquids in the trap are separated by a fractional distillation. The benzene is further purified by two more distillations and the final yield, at this time, is approximately 10 percent. It is anticipated that the yield can be substantially improved with further work. This material is then used as the solvent, and small amounts of PPO (2,5-diphenyloxazole) and POPOP [1,4-di(2-(5-phenyloxazolyl))benzene] are added as scintillator and wave shifter, respectively. In those cases where only a limited quantity of the material to be dated is available it is reasonable to use what benzene can be obtained and then to bring the solvent system up to volume with ordinary laboratory benzene, which is ancient in comparison to the 5568-year half-life of C^{14} and will not, therefore, contribute to the activity observed. Radon and fission product contamination are effectively removed by the distillations of the benzene and do not constitute a problem.

The counter used was a Tri-Carb liquid scintillation spectrometer (*5*). This instrument utilizes two matched photomultipliers connected to a coincidence analyzer that rejects most of the pulses that have their origin in electronic noise, largely within the photomultipliers. The noise level is further reduced by cooling these tubes to 6°C, which is just above the freezing point of benzene. The spectrometer is also equipped with two channels and scaling units, which were set to view the same portion of the spectrum and can be used in this way as continuous checks on the proper operation of the instrument. Windows permitting approximately 40 percent of the C^{14} beta particles to be counted were used and the background was about 13 count/min. This will eventually be lowered by use of quartz sample vials and more shielding. At this time the sample chamber is arranged to fit a counting vial that holds 20 ml, but this volume may be increased to 100 ml with minor modifications.

The method of benzene synthesis presented here is at least as simple as the other liquid scintillation counter methods described in the literature. It is inherently more sensitive than any of

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

the gas-counting methods and those liquid counting methods which include carbon that does not come from the sample being dated. Furthermore, the benzene method does not require a high vacuum rack or liquid nitrogen, which is not available in most places in the world.

The existing assembly is now capable of providing radiocarbon dates. Work is in progress to set up the operation on a routine basis and to increase the efficiency of the steps in the procedure to increase the yield. It is anticipated that the background can also be reduced considerably (*6*).

MURRY A. TAMERS
Department of Chemistry, University of Texas, Austin

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6. Assistance from the Robert A. Welch Foundation of Houston, Tex., is acknowledged.

17 May 1960

Effects of Temperature and Anions on Titration Curves of Frog Muscle

Abstract. Titration curves of frog muscle at 2°C and 25°C were determined in vivo. Lowered temperature decreases respiration without change of colloidal charge or of ion distribution as estimated from charge. Anions which are inhibitors or metabolites combine with muscle colloids, changing the distribution of other anions and cations.

Biological structures are amphoteric colloids which combine with organic and inorganic anions and cations, as well as with hydrogen ions. These ion-binding properties apply both to soluble and insoluble proteins (*1*). They have been studied in titration curves of colloidal surfaces (*2*). Many anions are strongly reactive and have marked effects on the titration curves of proteins and enzymes and on the binding of other anions and cations. The reactive anions include metabolic substrates as well as inhibitors. The effects are especially strong in reactions with insoluble protein aggregates.

Enzymes may occur in solution or as components of insoluble colloidal aggregates (*3*). According to the Michaelis-Menten formulation, combination with ions or molecules conforms to the mass action law, and is a condition for reactions with substrates or inhibitors (*4*). From these considerations, combinations with such substances would produce changes in electrolyte distribution simultaneously with changes in enzyme reactions. Rates of respiration and states of ion distribution both become dependent on the physicochemical state of the colloid and the chemical composition of the environment. It follows that the relation between cellular respiration and ion distribution is not direct, but that it involves colloidal structures of varying physicochemical states.

Experimentally, respiration may be changed by inhibitors or by temperature. In the first case, states of intracellular and extracellular colloids are simultaneously changed. Temperature changes, however, need not change the colloid, especially in *p*H ranges where protein titration curves are nearly independent of temperature. Experiments on the influences of temperature and of 2-4-dinitrophenol on the surface titration curves of frog muscle in vivo are reported here.

Fourteen frogs (*Rana pipiens*) were studied, seven at 25°C and seven in a cold room at 2°C. The frogs were pithed and the anterior thigh muscles were exposed. The overlying perimysium was scraped off to expose the sarcoplasm of the muscle fibres as confirmed by histologic examination. An electrometric method was used to determine the density of charge of the colloidal surface at a series of *p*H's between 7.4 and 2.2 (*5*). This is equivalent to a titration curve of the surface (*2*). The curve was then redetermined with the same series of isotonic saline solutions to which had been added 2-4-dinitrophenol at a concentration of 0.001*M*. The effects of *dl*-lactate, bicarbonate ion, sodium iodoacetate, and sodium cyanide were determined at *p*H 7.4 (Table 1). The compounds were chemically pure or reagent grade preparations.

In the method, described elsewhere in detail (*2*), two potential differences are determined between a reference site and the muscle surface. The reference junction is established by placing one leg in a 0.15*M* NaCl solution, while at the experimental site a solution of buffered 0.15*M* NaCl is applied by means of a moistened cotton pellet. Both reference and experimental junctions are connected through KCl-agar junctions to saturated KCl-calomel half cells, and a potential, E_1, is measured. A 0.015*M* NaCl solution is then applied at the experimental site, and the potential E_2 is measured. The difference $(E_2 - E_1)$ is termed the dilution potential, E_d. The displacement of potential observed with the dilute solution is expressed in millivolts. Depending on the sign of the colloidal charge, it is related to the charge density as follows:

$$E_d = E_d^\circ + kx \quad (1)$$

where x is negative colloidal charge, expressed as equivalents per kilogram of water (above the isoelectric point), or

$$E_d = E_d^\circ - ky \quad (2)$$

where y is the positive charge (below the isoelectric point) expressed in the same way. E_d° is the theoretical dilution potential at zero colloidal charge, and k is a constant which depends on temperature (*6*). Equations 1 and 2 have been derived for amphoteric colloidal surfaces consisting of one or more colloidal components. Potential differences refer to macroscopic sections of the muscle surface of about 1 to 4 mm² (*2*). These contain heterogeneous components of the sarcoplasm.

Results of the potentiometric determinations are presented (Fig. 1, Table 1). Values of x and y at two temperatures are plotted against *p*H to yield titration curves of the surface. The points have been fitted with the same curve, which shows an isoelectric point of about 3.25 (zero x and y). Curves observed with 0.001*M* dinitrophenol have likewise been plotted at two temperatures. These show displacements toward low levels of x; the displacements at 2°C are greater than those at 25°C. They resemble the displacements caused by picric acid at connective tis-

Table 1. Effects of anions on colloidal charge of muscle surface at 25° and 2°C. Change of colloid charge density values are means and change of potential values are means and standard deviations, of four to seven measurements.

Concn.* (*M*)	Temp. (°C)	Change of potential ($E_d - E_d'$)† (mv)	Change of colloid charge density ($x - x'$)‡ (equiv /kg water)
		2-4-Dinitrophenol	
0.001	25	4.4 ± 1.1	0.022
0.001	2	6.2 ± 0.6	.034
		Iodoacetate	
0.001	25	4.0 ± 0.5	0.020
0.01	25	4.6 ± 0.4	.023
0.01	2	6.0 ± 1.3	.030
		dl-*Lactate*	
0.01	25	3.4 ± 0.9	0.017
0.01	2	3.5 ± 0.3	.019
		NaCN	
0.001	25	3.9 ± 0.5	0.020
0.01	25	4.6 ± 0.2	.023
0.01	2	4.7 ± 1.1	.026
		$NaHCO_3$	
0.025	25	3.9 ± 0.3	0.020

* In isotonic NaCl-phosphate buffer at *p*H 7.4. † E_d is control value of dilution potential (−1.2 mv at 25°, and −1.6 mv at 2°). E_d' is the value of dilution potential in presence of given solution. ‡ Value of $(x - x')$, the change of colloid charge density, was calculated from Eq. 1, with the following values of k: 197 at 25°C, and 182 at 2°C.

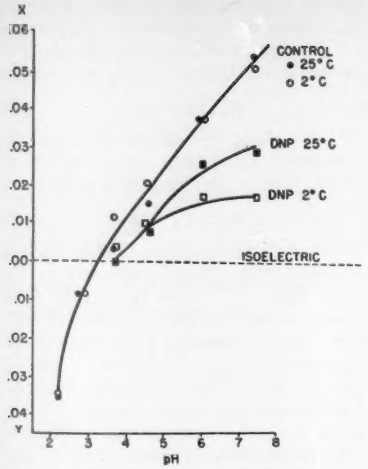

Fig. 1. Titration curves of frog muscle surface. Ordinate, density of colloidal charge in equivalents; abscissa, *p*H. Control curves at 2°C and 25°C are compared with curves observed with 0.001*M* 2-4-dinitrophenol.

sue or wool surfaces (*2*). Similar effects are shown by the other anions (Table 1). In titration curves of wool and connective tissues, many anions combine with protein to displace the curves in the same way.

Certain properties of the muscle surface studied in vivo may be compared with those determined in vitro. The negative charge density at *p*H 7.4 (0.053 equivalents; see Table 1) is lower than that of the isolated muscle proteins (0.100 equivalents) (*7*), but is consonant with that value when bound calcium, magnesium, and amines are taken into account. The fact that anions lower the negative colloidal charge has been discussed elsewhere (*2*). By forming salt linkages with positively charged groups, an anion *A* may increase the negative charge of the colloid *P*. For example,

$$P^{-} + A^{-} = (AP)^{--}$$

If this leads to the simultaneous binding of more than one hydrogen ion, the negative colloidal charge is decreased:

$$(AP)^{--} + 2H^{+} = (APH_2)$$

In the general case *P* would be polyvalent with numerous negative charges. The negative charge would be lowered by the simultaneous binding of anions and hydrogen ions to form the complex (APH_2). In the case of 2-4-dinitrophenol, the anionic O^- group would form a salt linkage with a positively charged amino group of the colloid. The two NO_2 groups would form hydrogen bonds simultaneously. In the process the Donnan ratio is changed, sodium is displaced, and chloride is simultaneously taken up by the surface (*2*). Other anions with strongly electronegative groups (NO_2, I, CN, CHOH) likewise coordinate by means of hydrogen bonds with conjugate electronegative groups (CONH, COO^-, SH, and so forth) of the colloid. In all cases a rearrangement of hydrogen and electrostatic bonds of the colloid would shift the titration curve. Because of the low bond energies which are involved, high labilities would be expected for anion-cation exchange reactions (*2*).

A direct relationship between ion distribution and the energy derived from cellular respiration has frequently been postulated, and appears under various guises as active transport of ions. The above experiments show that redistribution of anions and cations is produced by combination of respiratory inhibitors with extra- and intracellular charged colloidal aggregates. Anionic metabolites and inhibitors similarly alter the titration curves (and ion distributions) of connective tissues, as well as those of metabolically inert wool fibers and other colloids including ion-exchange resins. Lowering of respiration in poikilotherms by temperature reduction leads to no significant effect on colloidal charge or electrolyte distribution, although energy production is greatly diminished.

From this point of view, respiratory changes without simultaneous changes in colloidal state need not affect ion distribution. Inhibitors, which by definition decrease respiration, are bound to the colloidal matrix, and thereby produce redistributions of all other anions and cations (*8*).

MILTON B. ENGEL
HUBERT R. CATCHPOLE
NORMAN R. JOSEPH
Colleges of Dentistry, Medicine, and Pharmacy, University of Illinois, Chicago

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5. Buffer solutions were prepared at six different *p*H levels: 7.4, 6.0, 4.6, 3.7, 2.9, and 2.2. The ionic strength in each case was approximately 0.15. At *p*H 6 and 7.4, phosphate buffers were used, while acetate–acetic acid mixtures were used at *p*H 3.7 and 4.6. Sodium was the only cation present, while chloride accounted for 90 percent or more of the total anion concentration. NaCl-HCl mixtures were used at *p*H 2.9 and 2.2.
6. Below *p*H 3 the values of $E_a°$ depend on *p*H as well as on temperature. At 25°C the values of $E_a°$ in millivolts are −11.8 (*p*H 3.7 to 7.4), −10.1 (*p*H 2.9), and −4.2 (*p*H 2.2). At 2°C the corresponding values are −10.9, −9.3 and −3.9 mv. The values of *k* are 197 (25°C) and 182 (2°C). Methods of calculating these constants have been given (*2*).
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Cranial Capacity of Oreopithecus bambolii

Abstract. From a plaster reconstruction of the skull of the August 1958 skeleton, the cranial capacity of *Oreopithecus bambolii* has been estimated as falling between 276 and 529 cubic centimeters, thus within the ranges of variation of both orangutan and chimpanzee. In cranial capacity, therefore, and probably in body-brain ratio as well, *Oreopithecus* is a hominoid.

The taxonomic status of *Oreopithecus bambolii*, a fossil catarrhine primate from the Lower Pliocene of Italy, hence some 12 million years old, has been a matter of considerable controversy ever since the type specimen, a mandible with teeth, was described by Gervais in 1872 (*1*). In recent years, however, particularly following Hürzeler's discovery of a large number of additional specimens at Baccinello, Italy, it has become increasingly evident that *Oreopithecus* is a member of the superfamily Hominoidea, which comprises the families Pongidae (anthropoid apes) and Hominidae (man and his immediate forerunners) (*2*). This interpretation has been strengthened by studies of an adult skeleton discovered on 2 August 1958 (*3*). The precise allocation of *Oreopithecus* within the Hominoidea remains uncertain, however. The present communication deals only indirectly with this problem. Rather, it deals specifically with an attempt to estimate the cranial capacity of the 1958 skull, which is the only one sufficiently complete to justify such a procedure.

Although this skull is considerably crushed, its fragments fortunately remained closely associated within its lignite matrix. Its condition, however, precludes direct measurement of the cranial capacity. Some indirect method therefore must be employed. While we were in Basel in August, 1959, Dr. Hürzeler generously permitted us to study his plaster reconstruction of the skull and to take the basic measurement necessary for an estimation of its cranial capacity (*4*). This consists of an esti-

mation of the volume of the braincase by immersion in water and measurement of the consequent displacement of the liquid. Braincase volume in itself is of course no direct clue to cranial capacity. It is true that Jørgensen and Quaade (*5*) reported a close correlation between external cranial volume (representing the water displaced by that part of the skull above the horizontal glabella-inion plane) and cranial capacity in modern man, but their method is not applicable to all primates because of generic differences in skull form. If there were a relatively constant ratio between internal and external cranial volumes, determination of the cranial capacity of our fossil would be a simple matter. The ratio varies considerably, however, chiefly because of differences in relative thickness of the calvaria and cranial base. Therefore, in order to provide a basis for determining the probable limits of the cranial capacity of *Oreopithecus*, the ratio between cranial capacity and braincase volume has been calculated in a series of 21 adult catarrhine primates (*6*). Multiplying the braincase volume of the *Oreopithecus* plaster reconstruction by the extreme ratios of this series provides maximum and minimum estimates of the cranial capacity in this particular fossil.

The braincase, as defined in the present study, is that part of the cranium posterior to a plane passing from immediately behind the supraorbital ridges above through the lateral pterygoid plates below, as shown in Fig. 1. The volume of the *Oreopithecus* braincase, as thus measured from water-displacement of the plaster reconstruction, is 565 cc. This particular reconstruction, while excellent, naturally cannot be considered precise. Dr. Hürzeler himself did not regard it as entirely satisfactory in all details. Notwithstanding, we are of the opinion that, at least in so far as the size of the braincase is concerned, it cannot be greatly in error. On the assumption, however, that the reconstructed braincase may be either slightly too small or slightly too large, a correction factor of $\pm$ 75 cc seems in order. This allows for an error of reconstruction of approximately $\pm$ 0.5 cm in all dimensions. The volume of the braincase thus can be regarded as lying anywhere between 490 and 640 cc. Hence, both of these limits have been used in estimating the cranial capacity of *Oreopithecus* (see Table 1) (*7*). The smallest cranial-capacity/braincase-volume ratio in the series of primates measured by us is that of an orangutan, 0.564; the largest is that of a gibbon, 0.826 (Table 1, column a/b). By applying these, respectively, to the minimum (Table 1, column 490 $\times$ a/b) and maximum (Table 1, column 640 $\times$ a/b) braincase volumes estimated for the *Oreopithecus* skull, limits of 276 and 529 cc are obtained. The cranial capacity of the August 1958 specimen thus can reasonably be regarded as anywhere between 276 and 529 cc.

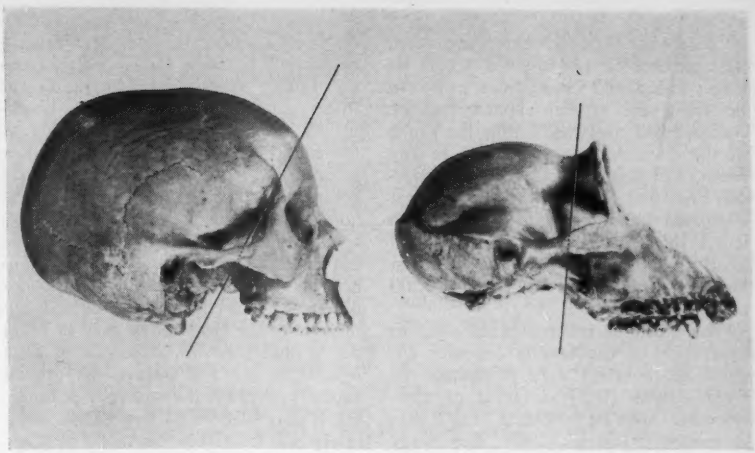

Fig. 1 Skulls of adult female Negro (left) and adult male chimpanzee (right), showing the line of demarcation between facial skeleton and braincase used in this study. The braincase, as herein defined, is that part of the cranium posterior to a plane passing from immediately behind the supraorbital ridges, above, through the lateral pterygoid plates, below.

Can it be more than mere coincidence that these calculated extremes, 276 and 529 cc, not only are almost identical with the measured limits of variation, 276 and 523 cc, in the combined series of 194 adult orang-utan skulls studied by Gaul and by Schultz (*8*) but also agree closely with the 290 and 500 cc limits in the combined series of 94 adult chimpanzee skulls measured by Zuckerman and by Schultz (*9*)? Whatever this may signify, the cranial capacity of this *Oreopithecus* skull almost certainly falls within the ranges of variation of these two great apes. The cranial capacity of the adult gorilla

Table 1. Cranial capacities in cubic centimeters (column *a*), braincase volumes in cubic centimeters (column *b*), and the ratio between cranial capacity and braincase volume (column a/b) in 17 extant and 4 fossil adult catarrhine primates; and possible cranial capacities, in cubic centimeters, of *Oreopithecus*, secured by multiplying its estimated braincase volumes by the various values of ratio a/b (columns 490 $\times$ a/b, 565 $\times$ a/b, 640 $\times$ a/b).

Primate	*a*	*b*	a/b	490 $\times a/b$	565 $\times a/b$	640 $\times a/b$
Macaca mulatta ♂	99	133	0.744	365	420	476
Macaca mulatta ♀	87	115	.756	370	427	484
Papio sphinx ♀	148	187	.791	388	447	506
Presbytis melalophus ♂	66	91	.725	355	410	464
Hylobates agilis ♂	95	115	.826	405	467	529
Symphalangus syndactylus ♂	127	179	.709	347	401	454
Orang-utan ♀	417	717	.581	285	328	372
Orang-utan ♀	353	625	.564	276	319	361
Chimpanzee ♂	430	692	.621	304	351	397
Chimpanzee ♀	378	563	.671	329	379	429
Gorilla ♂	593	978	.606	297	342	388
Gorilla ♀	463	788	.587	288	332	376
Gorilla ♀	478	833	.573	281	324	367
Australopithecus (Sterkfontein No. 5)	480(*14*)	782	.613	300	346	392
Neanderthal (La Chapelle-aux-Saints)	1626(*15*)	2168	.750	368	424	480
Neanderthal (Gibraltar No. 1)	1250(*16*)	1665	.750	368	424	480
Rhodesian Man	1280(*17*)	1890	.677	332	383	433
Negro ♂	1280	1775	.721	353	407	461
Negro ♂	1627	2025	.803	393	454	514
Negro ♀	1133	1478	.766	375	433	490
Negro ♀	1323	1765	.749	367	423	479

is somewhat greater, extending from 420 to 685 cc (*10*). Even so, if its larger calculated possibilities prove to be valid, the cranial capacity of the Italian fossil also lies within the range of the giant African great ape. In any event, the cranial capacity of *Oreopithecus* is that of a hominoid. Its lowest estimated capacity, 276 cc, is much larger than that recorded for any Old World monkey; the capacities of even large adult baboons fall short of 200 cc (*11*).

The index of relative brain size, an expression of the cranial capacity (in cubic centimeters) as a percentage of body weight (in grams), is of considerable interest. Schultz (*12*) has reasonably argued that the body weight of the 1958 specimen of *Oreopithecus* must have been about 40 kg, which approximates the weight of the average chimpanzee or female orang-utan. With this figure, the body-brain index of the fossil could be as little as 0.69 or as much as 1.32. The minimum index, 0.69, lies well within the adult range of variation for the three great apes (*11*). The maximum index, 1.32, while considerably above that recorded for any adult gorilla, is but slightly larger than the adult maxima of both the orang-utan and chimpanzee; it is slightly smaller, however, than the minimum index for adult man (*11*). Both of these estimated *Oreopithecus* indices are paralleled among Old World monkeys. However, this index of relative brain size tends to be inversely proportional to body weight in primates (*11*). Consequently, if its larger index, 1.32, is valid, *Oreopithecus* can be regarded as somewhat advanced in relative cranial capacity and hence in relative size of brain, for it undoubtedly was a much bigger animal than any Old World monkey of comparable body-brain index. Indeed, this index falls below 1.0 in all Old World monkeys weighing more than 10 kg (*11*).

Its encephalic magnitude, both absolute and relative, confirms the assignment of *Oreopithecus* to the Hominoidea. It is not permissible, however, from this character alone, to allocate that fossil more precisely. Although the degree of its encephalic development is equivalent to that found in existing great apes, it does not of necessity follow that *Oreopithecus* belongs in the family of the great apes, the Pongidae. For one thing, we lack the truly requisite comparative data, since we are quite ignorant of the cranial capacities of the undoubted Lower Pliocene ancestors of the great anthropoids; hence we do not know whether the pongid brain of that time had as yet attained its present size. Nor does its relatively moderate cranial capacity necessarily exclude *Oreopithecus* from the family Hominidae; for a Lower Pliocene hominid would scarcely be expected to possess a brain as large as those of undoubted men, since it now is quite evident that the brain lagged behind the rest of the body during hominid phylogeny (*13*). Hence, despite brains that were of great-ape dimensions, the early Pleistocene "man-apes" of South Africa, the australopithecines, have not been denied admission to the Hominidae. Size of brain per se therefore would not debar *Oreopithecus*; for not only is its cranial capacity within the great-ape range, but it may well be as large, both absolutely and relatively, as those of some australopithecines (for example, *Australopithecus* [Sterkfontein No. 5]; see Table 1, column *a*). Thus, although the cranial capacity definitely identifies *Oreopithecus* as a member of the Hominoidea, it is of no aid in deciding whether this creature belongs in the Pongidae, the Hominidae, or a family of its own.

WILLIAM L. STRAUS, JR.
MIGUEL A. SCHÖN
Department of Anatomy,
Johns Hopkins University,
Baltimore, Maryland

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7. Each of the braincase volumes in Table 1 (column *b*) represents an average of three separate measurements. The volumes of the 4 fossil hominids were measured from standard plaster casts. Forty cubic centimeters have been subtracted from the measured *Australopithecus* volume because the infratemporal fossae are filled by foreign material, and 40 cc have been added to the measured La Chapelle-aux-Saints volume to account for defects in the skull. To prevent water from entering the cranial cavities of the actual skulls, all relevant foramina were first plugged with raw cotton and then sealed, together with any open sutures, with paraffin. In each instance, the volume measurement has been corrected to account for the paraffin and cotton. Corrections also have been made for prominent nuchal and sagittal crests; wherever feasible, these have been reconstructed in modeling clay (Plastolene), and the water displacement has been measured. The cranial capacities of the 4 fossil hominids have been taken from the literature. Those of all other skulls were measured by us, using small dried peas; each figure in Table 1 (column *a*) is an average of three separate measurements.
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1 August 1960

Differential Sensitivity of Peripheral Retina to Intermittent White Light

Abstract. The ability of the eye to detect differences in the interruption rate of white light was investigated for various rates and for several locations on the temporal periphery of the right eye. The complex relationship previously reported was again found, but only for stimulation of the fovea. The results from the peripheral regions indicate that differential sensitivity is a decreasing function of the rate of intermittence.

Within recent years the differential sensitivity of the fovea to intermittent white light has been investigated several times, always with the same result (*1, 2*). Simply stated, the differential sensitivity appears to be a complex function of the rate of intermittence, decreasing as the rate of intermittence increases to 22.5 cy/sec, after which it increases sharply to the neighborhood of 35 cy/sec and then decreases again as the fusion point is approached. The luminance of the flickering source was such that fusion occurred in the neighborhood of 40 cy/sec for all observers. This effect has been found for numerous observers with different psychophysical methods and different on-

off ratios of the flickering stimulus source (*2*).

Since all of the data reported so far have been obtained from foveal measurements, it was decided to investigate the peripheral retina before concluding that the effect observed is a general one.

The intermittent stimulus light was produced by a Sylvania R1131C glow-modulator tube operated independently from two variable-frequency square-wave generators. The stimulus spot subtended 0.5° of visual angle and had a homogeneous luminance of 1800 mlam. It appeared in the center of a white, semicylindrical surround with a fixed luminance of 22 mlam. Small, dim fixation lights were so positioned that when viewed foveally the stimulus spot stimulated points 5°, 10°, 15°, 20°, or 30° peripheral to the fovea on the temporal retina of the right eye. The observer's position was maintained at the center of curvature of the surround by a fixed chin-and-forehead-rest. Foveal judgments were obtained by having the observers fixate the stimulus spot directly.

The observer sat in a room darkened except for the light from the surrounding field. The standard and comparison channels were programmed through one cycle so that each was presented for 1 second with a 1-second interval between. The initiation of this cycle was under the control of the observer. Half of the judgments were made with the standard presented first and half with the comparison presented first. The observer also controlled the frequency of appearance of the comparison stimulus by a linear, multirevolution potentiometer. Equality judgments were obtained by the method of adjustment, with ascending and descending matches alternately. All observers were allowed to view as many cycles of the standard and variable as they felt necessary. The discrepancy between the standard and the comparison frequency was measured by an electronic counter to an accuracy exceeding that of the generating equipment.

Six observers were given practice in making this type of judgment before any experimental data were collected. After the practice sessions each observer made from 9 to 18 judgments at each retinal position for each of the following interruption rates: 5, 10, 15, 20, 22.5, 25, 30, and 35 cy/sec. Combinations of frequency and retinal position were presented in a random order. Three consecutive thresholds were obtained for each condition before a different condition was imposed.

The pooled results obtained from all six observers are shown in Fig. 1, where the difference-limen (Δf) and the relative difference-limen ($\Delta f/f$) are plotted as a function of the interruption rate for all retinal positions. Each plotted point is based on a total of 66 to 84 judgments. This range of judgments per point is due to two factors. First, not all observers provided the same number of judgments for each condition because of scheduling difficulties and time limitations. Second, in making tedious and patience-demanding judgments of the type required here, occasional aberrant readings are produced that are entirely unrepresentative. Therefore, those readings that exceeded the average deviation (computed with the aberrant reading included) by a factor of 3 were excluded. The judgments so excluded represented only 2.3 percent of the total.

The data from the fovea (0°), plotted in Fig. 1, resemble closely those obtained in previous experiments. The difference-limen here is somewhat higher over-all than those reported earlier. This may be a result of the different experimental conditions under which these data were collected.

The results from the peripheral retina do not exhibit the same complexity that has been found for the fovea. Neither does there seem to be any consistent effect on the difference-limen as a result of viewing the stimulus spot at different points on the peripheral retina, except perhaps for the increased variability of the threshold judgments in the far periphery as compared with the near. This latter result is not surprising in view of the difficult nature of peripheral judgments. Small stimuli viewed obliquely are subject to a rapid adaptation or fading that increases with eccentricity (*3*). Therefore the time available to make rate judgments in the periphery is much more limited than in the fovea. What is surprising is the fact that the differential-limens for flicker rate are practically identical for all areas of the

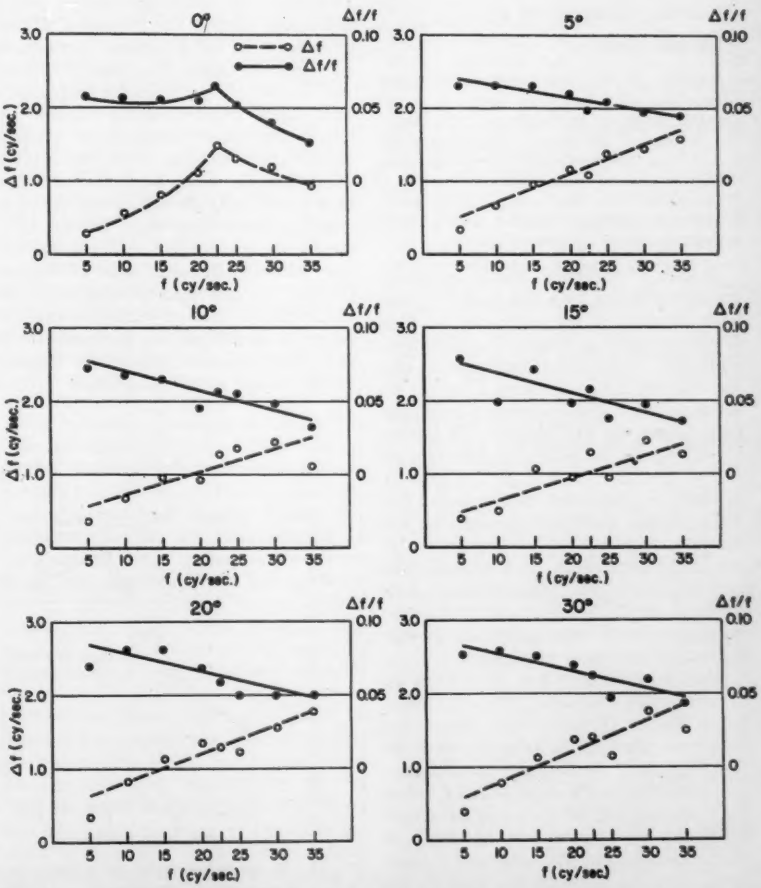

Fig. 1. The differential-limen (Δf) and the relative differential-limen ($\Delta f/f$) for intermittent white light. The data are measurements from different regions of the temporal retinae of six observers.

temporal retina that lie outside of the fovea. One must conclude that the complex function describing the differential sensitivity of the eye to intermittent white light is somehow peculiar to foveal stimulation. The precise nature of this peculiarity is yet to be revealed (*4*).

G. H. MOWBRAY
J. W. GEBHARD
Applied Physics Laboratory,
Johns Hopkins University,
Silver Spring, Maryland

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5 May 1960

Observing Behavior in a Vigilance Task

Abstract. It has been suggested that level of performance in a vigilance task is accurately reflected by frequency of observing responses. By means of photography it has been demonstrated that under conditions where a decrement in vigilance performance does not occur, the frequency of nonobserving behavior and general activity increases in time.

Studies of vigilance, that is, monitoring performance as a function of time, have recently raised questions of theoretical as well as practical importance. Holland (*1*) studied frequencies of observing responses—pressing a key to illuminate the display—during a vigilance task. Using the Mackworth (*2*) schedule of signals occurring at intervals of ¾, ¾, 1½, 2, 2, 1, 5, 1, 1, 2, 3, and 10 minutes, in that order, and repeated for three further half-hour periods, he reported a decrement in performance and a parallel decrement in observing rate and concluded that "the detection data of vigilance studies may reflect the observing response rates generated by the particular schedules employed."

Holland defined a key depression as an observing response. On the other hand, Blair (*3*) stated that "observing responses refer to the relation, through time, between sense-organ orientation and displays . . . the depression of a key may or may not be the same as actual head and eye movements involved in monitoring tasks." He arranged a vigilance situation in which the presence or absence of a signal could be detected only when the head was oriented toward the display. Only two of his five subjects exhibited behavior such as Holland described. Blair did not present data on detection performance, nor did Carpenter (*4*), who found that frequency of blinking increased during a vigilance task.

During six vigilance experiments, I registered general activity or "restlessness" by means of counters activated by microswitches placed under the subjects' pivotally mounted chair (Baker, *5*). I found that whereas general motor activity increased markedly in time "there is little possibility of predicting the level of vigilance from motor activity during the task."

Since key pressing is a form of motor activity, the Blair, Carpenter, and Baker studies raise a question about the generality of Holland's tentative conclusion. To examine this question, a Mackworth-type clock test was devised having a single hand jumping forward to a new position once a second, 100 jumps per revolution. Double jumps, designated as signals, occurred as per the Mackworth schedule. The clock face was a Lucite panel behind which a 16 mm camera was mounted. Photographs (1/32 sec exposure) were taken of subjects' heads and shoulders once per second for an hour. A ring-shaped fluorescent tube mounted around the clock permitted satisfactory photography and rendered the camera invisible. Subjects were not informed that they were being photographed, and possible auditory cues were deleted by a steady masking noise plus ear defenders. Viewing distance was 20 inches. [Fraser (*6*) has reported that when the clock test is used at such viewing distances a decrement in performance is not demonstrable, presumably because of the large signal magnitude (*7*); a decrement was not required for our purpose.] In addition, microswitches under the subjects' pivotally mounted chair gave a measure of general activity or "restlessness."

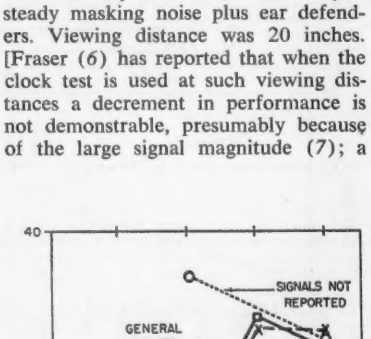

Fig. 1. Mean percentages of general activity, nonobserving responses, and signals not reported, as functions of time. Data for signals not reported are plotted for half-hour periods.

The task was to press a button when a signal was detected. Subjects were 19 paid housewives.

The data consisted, then, of the number of signals reported, a record of general activity, and 64,698 photographs (*8*). An observing response was defined as eyes open and oriented toward the display. A decision as to whether subjects met the criteria of an observing response was made by two judges who together examined the photographs and reached agreement in each case. When not meeting the criteria, subjects were blinking, yawning with eyes closed, turning to look behind, reaching down toward the floor, looking overhead, and so forth.

Percentages of time the subjects observed the display ranged from 90.6 to 99.4 with a mean of 97.2 and a median of 98.2. The frequency distribution of nonobserving responses (which consumed an average of 2.8 percent of the hour) showed a marked change with time: 16.8 percent occurred in the first quarter-hour and 31.4 percent in the last. This difference is significant at the 0.01 level. General activity showed a parallel increase, 16.4 percent of the activity occurring in the first quarter-hour and 29.6 percent in the last, a difference also significant at the 0.01 level. These percentages are very similar to those previously reported (*5*).

There was no decrement in number of signals reported, 36 percent of the signals not being reported in the first half-hour and 30.7 percent in the second. The difference is not significant. (In only one case was the subject actually not observing the display when a signal occurred.)

Figure 1 shows how closely the increasing frequency of nonobserving responses paralleled increasing general activity, while neither paralleled the frequency of signal reports (*9*).

Three Spearman rank-difference coefficients were calculated between the total values of the three variables recorded for each subject, and none differed significantly from zero. To consider one case only, the subject who spent the lowest percentage of time observing the display (90.6) had the smallest record of total general activity over the hour and failed to report only three signals (all appearing in the first half-hour). It is recognized, of course, that in a situation where the range of nonobserving responses is much greater than that reported here a relation must exist with the number of signals reported.

However, in this experiment the fre-

quency of nonobserving responses and degree of general activity were independent of one another for each subject, and although both increased with time neither was related to performance on the vigilance task used (*10*).

C. H. BAKER

Defence Research Medical Laboratories, Defence Research Board, Toronto, Canada

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25 April 1960

Sex Chromatin in Mammalian Bone

Abstract. The presence of a sex chromatin body similar to that reported in other tissues has been demonstrated in the nuclei of osteoblasts, osteocytes, and periosteal cells from female dogs and cats.

Since 1949, when Barr and Bertram (*1*) first described a histologic sex difference in the neurons of the female cat, the presence of the nuclear sex chromatin body has been noted in a variety of cells from different species (*2*–*5*). In man, it has been studied extensively in the nervous system (*6*), polymorphonuclear leukocytes (*7*), epidermis (*8*), and mucous membrane (*9*). It has also been observed in the cells of the amniotic fluid, the placenta, and the fetal membranes (*10, 11*). In animals other than man an even greater number of cell types have been examined (*4*). Only a few species did not exhibit a visible nuclear sex difference (*2*). In any animals in which the sex chromatin body could be identified, it was demonstrable in all of the tissues that were investigated.

Table 1. Incidence of the sex chromatin body in the bone and periosteal cells of female animals (fewer than 10 percent of cells in male animals showed a similar structure).

No.	Cells with sex chromatin (%)		
	Periosteum	Osteoblasts	Osteocytes
		Adult cat	
4	76	53	48
		Adult dog	
4	72	52	50
		Puppy	
4	79	76	73

The presence of a sex chromatin body in bone has not been previously reported. We do not know whether this tissue has actually ever been studied, or if technical difficulties in fixation and decalcification have prevented the proper examination of nuclear detail. The purpose of this investigation was to disclose whether the sex chromatin body could be observed in the bone of animals known to exhibit a histologic sex difference in other tissues (*12*).

Eight adult dogs, eight cats and eight 6-week-old puppies, equally divided according to sex, were used for this study. The animals were killed with a lethal dose of sodium pentobarbital, and portions of rib and tibia, including the periosteum, were removed and immediately placed into modified Davidson's solution (alcohol-formalin-acetic acid). After fixation for 48 hours the specimens were transferred to an aqueous solution of ethylenediaminetetraacetic acid at *p*H 7.4. Periodic radiographic examination of the tissue samples was used to determine the degree of decalcification. After decalcification the specimens were washed, dehydrated in alcohol, and embedded in paraffin. Sections were cut at 7 to 10 μ with a rotary microtome. The tissues were stained with Stowell's modification of the Feulgen-Schiff technique (*13*) and counterstained with fast green dye.

The stained specimens were examined under oil emersion at magnifications of 900 and 1250. The criteria used for recognition of the sex chromatin body (size, shape, position, and Feulgen-positive staining properties) were based upon previous descriptions for other mammalian cells (*1, 5*). Identification of the sex chromatin was originally established in samples of bone tissue from four cats and four dogs of known sex. Subsequently, the sex determination of unidentified coded specimens was based upon the percentage of 100 well-preserved cells containing the sex chromatin body. Cell counts limited to one particular field could not be made in compact bone because of the difficulty in obtaining uniform cellular fixation.

The sex chromatin body could be identified in osteoblasts, osteocytes, and periosteal cells of the bone tissue from female dogs and cats (Table 1). In appearance, it was similar to that which has been seen in other mammalian tissues. Generally, it was the largest chromatin mass within the nucleus. It could be readily distinguished from the nucleolus by its differential staining properties. Due to the high deoxyribonucleic acid content, the sex chromatin body appeared red with the Feulgen stain whereas the nucleolus, containing mainly ribonucleic acid, was colorless. In counterstained specimens, the nucleolus was light green.

Fig. 1. Osteocytes in bone from female puppy. The sex chromatin appears as a planoconvex body at the nuclear-cytoplasmic junction. Feulgen stain (×1100).

In most instances, the sex chromatin body appeared as a centrally projecting, deeply stained, planoconvex-shaped mass approximating the nuclear-cytoplasmic junction (Fig. 1). Occasionally it assumed a triangular or flattened form. Although the sex chromatin body has sometimes been described as appearing in a more central position within the nucleus (*5*), contact with the nuclear-cytoplasmic junction was used as a criterion in this study.

The sex chromatin body was most readily observed in cells with well-

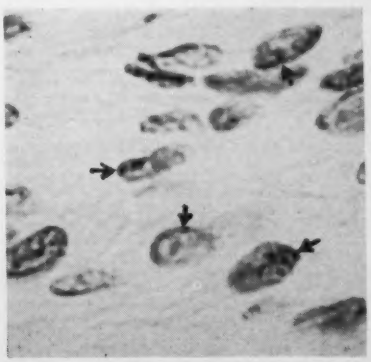

Fig. 2. Periosteum from female dog showing the high incidence of visible sex chromatin bodies. Feulgen stain (×1100).

preserved vesicular nuclei. Thus, periosteum and young bone provided the best material for study (Figs. 1, 2). In these tissues the sex chromatin body could be recognized in about 75 percent of the cells (Table 1). In adult bone, approximately 50 percent of the nuclei contained an identifiable sex chromatin body. These figures compare favorably with the reported observations in other tissues of the dog and cat (*2, 4*). In sections of bone from male animals less than 10 percent of the cells contained a nuclear chromatin mass of a size, shape, and position comparable to that which is found in the female. Of the unlabeled coded sections from the 16 animals that were investigated, all were correctly identified according to their sex source.

Although the significance of the sex chromatin body has not been established, its recognition in tissues has led to many important clinical applications. Thus, it has been used extensively in prenatal sex determinations, in studies of infertility, and in distinguishing the chromosomal sex of individuals with congenital errors in sexual development (*10, 14*). Experimentally, the presence of a histologic sex difference in cells also provides a useful physiologic tag for studying grafted tissues (*15*). As a result of the findings in the present investigation, this technique is now being used to evaluate the fate of bone homografts.

DANIEL M. VERNINO
DANIEL M. LASKIN
University of Illinois College of Dentistry, Chicago

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3 June 1960

Acrylic Acid, an "Antibiotic" Principle in Phaeocystis Blooms in Antarctic Waters

Abstract. An acidic algal substance has been isolated and characterized as the sodium salt. Synthetic sodium acrylate possesses chemical and antibacterial properties identical with those of the natural product. This observation identifies the algal substance in the stomach contents of euphausids, the diet of pygoscelid penguins, which inhibits the penguin gastrointestinal microflora.

A substance which inhibited the gastrointestinal microflora of pygoscelid penguins (*1*) was traced to the phytoplankton-laden stomach contents of their euphausid diet (*Euphausia superba*) and then to a green mucilaginous colonial alga (*2*). The purpose of this report is to describe the isolation of an antibacterial substance from the mucilaginous colonial alga, *Phaeocystis*, and the identification of this substance as acrylic acid (*3*).

The phytoplankton communities in the Gerlache and Bransfield straits off the west coast of Palmer Peninsula were studied in January and February 1959. Antibiotic assays and microscopic examination of concentrates of plankton gathered by net indicated that antibacterial activity against *Staphylococcus aureus* and *Mycobacterium smegmatis* is correlated with the predominance (40 to 90 percent) of a species of *Phaeocystis* (similar to *P. pouchetii*) in the blooms. Algal concentrates (5.1 percent dry wt.) of *Phaeocystis* were obtained with a number 2 net which retained these mucilaginous algae but permitted most of the diatoms to pass through. These preparations were stored in polyethylene bottles at −20°C aboard ship, transported in dry ice, and maintained in the laboratory at −55°C.

Air drying on glass plates, desiccation in a vacuum, and lyophilization of the algal concentrates caused an approximately 20-fold reduction in activity. Extraction of this dried material, as well as the wet algae, with acetone, ethers, and alcohols produced concentrates which lost their activity rapidly at 5°C. The formation of inactive gummy material usually occurred as a result of the numerous abortive attempts to concentrate and purify the antibacterial substance. Distillation of acidic algal supernatants produced antibacterial distillates which failed to leave an active residue after evaporation.

A virtually pure active solid has been obtained only by the following procedure. The supernatant fluid of thawed cells (*p*H 5.5) was adjusted to *p*H 3.0 with HCl or H_2SO_4. The acidic substance readily volatilized under reduced pressure (in a Rinco rotating vacuum-type evaporator) to yield an active condensate (*p*H 3.7) in the solvent recovery condenser. Barium chloride and silver nitrate tests on the condensate indicated that the mineral acids used for acidification were absent. After careful adjustment of the *p*H to the equivalence point (*p*H 7.5) with NaOH, evaporation in a vacuum yielded an active sodium salt. Recovery of the original activity was increased from 80 percent to virtually 100 percent by the use of additional ice traps in the vacuum line.

Titration curves on the acid condensate as well as the weight of the sodium salt formed at equivalence were used to calculate neutralization equivalents of 92 to 99. Analysis of the sodium salt was 35.39 percent carbon and 3.6 percent hydrogen. Sodium fusion elemental analyses were negative for sulfur, nitrogen, and halogens. Qualitative tests indicated the absence of carbonyl and hydroxy groups, while the rapid color changes in bromine and potassium permanganate solutions indicated unsaturation. These data suggested that acrylic acid (CH_2=CH—COOH), the sodium salt of which has a neutralization equivalent of 94 and a composition of 38.3 percent carbon and 3.2 percent hydrogen, was a likely possibility.

The monomer was extracted from a partially polymerized commercial preparation of acrylic acid and used to prepare sodium and calcium salts in the same manner as the algal material. The infrared spectra of the natural and synthetic preparations of sodium acrylate and calcium acrylate, determined by a Beckman IR-5 infrared spectrophotometer, were found to be identical. Filter paper disk antibacterial assays (on *p*H 6.5 heart infusion agar, Difco) of the natural and synthetic salts against 12 microorganisms were used to calculate the minimum inhibitory concentrations. The results presented in Table 1 indicate identical spectra of activity. Ascending filter paper chromatograms and x-ray diffraction analyses also

Table 1. Antibacterial spectrum of natural sodium acrylate from *Phaeocystis* and the synthetic salt.

Test organism	Minimum inhibitory concn. (mg/ml)	
	Synthetic	Natural
Pasteurella multocida	0.025	0.030
Corynebacterium pseudodiphtheriticum	0.21	0.21
Mycobacterium smegmatis	0.35	0.35
Streptococcus pyogenes	0.6	1.3
Staphylococcus aureus	0.8	1.6
Proteus vulgaris	2.5	2.5
Candida albicans	4.5	9.0
Escherichia coli	4.8	5.0
Sarcina lutea	5.0	5.0
Klebsiella pneumoniae	25.0	38.0
Torula lactosa	> 50.0	> 50.0
Aspergillus fumigatus	> 50.0	> 50.0

yielded identical data for both the natural and synthetic preparations.

Acrylic acid, which is known as a toxic chemical, is apparently nontoxic to at least certain animal tissues in dilute solutions. The free acrylic acid content of the *Phaeocystis* preparations was calculated to be 0.38 percent (7.4 percent dry wt.). This level was apparently nontoxic for euphausids which were grazing on *Phaeocystis* blooms and whose stomach contents had antibacterial activity identical with that of the algae upon which they were feeding. Concentrations of acrylic acid sufficient to cause inhibition of the penguin gastrointestinal microflora were apparently nontoxic to the penguins. Preliminary tests in mice indicated that 700 mg of sodium acrylate per kilogram of body weight, injected intramuscularly, were well tolerated. However, *Phaeocystis* blooms which foul herring nets in the North Atlantic Ocean were believed to exclude herring (*4*), and the mucilaginous colonial form of *P. pouchetii* in culture has been observed to be toxic for herring fry (*5*).

The natural occurrence of appreciable amounts of acrylic acid in *Phaeocystis* raises some very interesting questions about its precursor, its function in the algae, its mode of antibacterial action, and its effect on the physiological ecology of the marine habitat. Apparently the only reports on the natural occurrence of acrylic acid in marine plants concern investigations of the precursor of dimethyl sulfide (*6*) in the epiphytic intertidal alga, *Polysiphonia lanosa*. Dimethylpropiothetin, which occurred in considerable amounts, was easily cleaved with heat or alkali (*7*) or by an enzyme (*8*) to form dimethyl sulfide and acrylic acid. Preliminary attempts to show the presence of this precursor or dimethyl sulfide in *Phaeocytis* were inconclusive. The mucilaginous substances in the colonial form of *Phaeocystis* may be acrylic polymers. Although substituted acrylates have been tested for their antibacterial activity (*9*) the activity of the parent compound has evidently not been reported. Possible modes of antibacterial action may be the inhibition of D-amino acid oxidase (*10*) or propionate oxidation (*11*). Acrylic acid may have antialgal properties, since *Phaeocystis* replaced the diatoms in certain areas to become the predominant form. Acrylic acid apparently affects green plants (*12*) and may inhibit photosynthesis. Studies are in progress to further elucidate the role of acrylates in the physiological ecology of the Antarctic marine habitat (*13*).

JOHN MCNEILL SIEBURTH
Department of Veterinary Science, Virginia Polytechnic Institute, Blacksburg

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13. I would like to gratefully acknowledge the many individuals who have contributed to the various stages of this investigation: among others, these include Drs. Paul R. Burkholder, Sidney Galler, A. B. Borkovec, B. W. Nelson, Cap. de Corb. Carlos Mayer, Mrs. Nancy P. Oakey, and Mrs. Barbara C. Duke.

10 February 1960

Completion of Meiosis in Uninseminated Eggs of Drosophila melanogaster

Abstract. Contrary to earlier statements, meiosis goes to completion in "unfertilized" eggs of *Drosophila melanogaster*. Evidence suggests that this is not only characteristic of the strain examined but of the species as a whole and of other *Drosophila* species as well.

The earliest reference to meiotic figures in the "unfertilized" (that is, uninseminated) eggs of *Drosophila melanogaster* is that of Huettner, who stated, ". . . maturation does not take place unless the egg is fertilized" (*1*). No evidence was presented in support of this statement, and yet the idea that meiosis does not continue beyond metaphase of the first division unless sperm enter the egg has become incorporated into the literature (*2*). The situation has been examined by analysis of eggs laid by virgin females (*3*, for preliminary report).

Eggs collected at half-hour intervals from individual virgins of an Oregon-R strain were aged from ½ to 2 hours at 25°C, sectioned, and stained with Heidenhain's hematoxylin. As an extra precaution, egg samples were collected prior to and after those used for sectioning and were incubated to make certain that none of them hatched.

Cytological details were studied in 93 sectioned eggs. In every case meiosis had gone to completion, contrary to views expressed in the literature. In 20 of these eggs, four interphase or

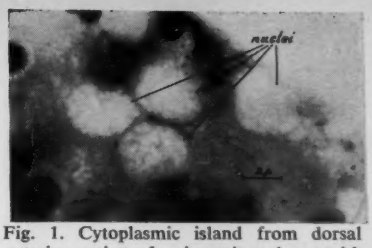

Fig. 1. Cytoplasmic island from dorsal anterior region of uninseminated egg with the four nuclear products of meiosis.

prophase nuclei were found and identified as the products of maturation (Fig. 1). The remaining eggs contained one, two, or three groups of metaphase chromosomes whose appearance often resembled the polar body chromosomal groups described in fertilized eggs (*4*), with spindle elements usually discernible.

The sequence of events following maturation varies, depending upon which of the meiotic products fuse with one another. Counts made of the number of chromosomes in various groups indicate that two, three, or even four nuclei may come together and fuse. The innermost or outermost chromosomal group, or both, appear to be omitted from the fusion product when it involves only two or three nuclei. With the completion of meiosis, a cytoplasmic extension forms, along which the female pronucleus, or metaphase fusion product, may or may not pass to the center of the egg, even though sperm have not entered. It seems probable that the fusion product in older degenerating eggs is the figure assumed to represent the first meiotic division in previous papers.

The possibility exists that the completion of meiosis in uninseminated eggs is a feature peculiar to the Oregon-R strain examined. However, other evidence supports the view that it is a more general phenomenon and probably represents the rule rather than the exception in *Drosophila*. First, a somewhat similar description of "unfertilized" eggs has been given for *D. funebris* (*5*), although no systematic investigation of the situation was reported. Second, Guyénot and Naville (*6*) noted an occasional first meiotic division anaphase spindle, as well as second division spindles in "unfertilized" eggs of *D. melanogaster*. Further support comes from recent studies of parthenogenesis in *Drosophila*. Genetic (*7*) and cytological (*8*) evidence has been presented for the fusion of haploid nuclei after the completion of meiosis in *D. parthenogenetica*. In this species, continuation of meiosis beyond Meiosis I has been described (*8*) in "unfertilized" eggs of a uniparental parthenogenetic line and also in some eggs from a biparental line. Cytologi-

cal events leading to parthenogenesis in *D. mangabeirai* have also been reported (*9*). The evidence again points to an automictic type with fusion of haploid nuclei following the completion of maturation divisions.

Completion of maturation in the "unfertilized" eggs of other insect genera is not always associated with parthenogenesis. For instance, in the grasshopper, *Melanoplus*, maturation divisions proceed in essentially the same way as in eggs which receive sperm (*10*). Here the stimulus for eggs to develop beyond metaphase of the first division evidently acts during the process of egg laying. This also may be true of *D. melanogaster* (*11*).

W. W. DOANE
Osborn Zoological Laboratory, Yale University, New Haven, Connecticut

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20 June 1960

Regeneration of Hydra from the Endoderm

Abstract. The endoderm of hydra, when cultured independently, can differentiate so that the total animal is reconstituted. Reconstitution or regeneration, or both, occurs without the demonstrable aid of the interstitial cells.

Two theories are held concerning the regeneration of hydra. One states that interstitial cells must be present for regeneration to take place and that the interstitial cells differentiate into the new cells of the regenerate (*1*). Papenfuss and Bokenham (*2*) claimed that the constituents of both cell layers were necessary. Brien and Reniers-Decoen (*3*) and Chapman and Tilney (*4*) have followed the differentiation of the interstitial cells and concluded that they function to form gametes and nematocysts.

However, Kanajew (*5*), employing histological techniques, traced vitally stained cells in the regenerates and concluded that endoderm may be formed solely from pre-existing endodermal cells without the aid of the interstitial cells. Tokin and Gorbunowa (*6*) and von Bertalanffy and Rella (*7*) demonstrated that total regeneration of hydra can take place from a reaggregated mass of cells obtained from the pedal disc. Histologically, only endodermal and ectodermal cells are present in the pedal disc. In addition, Brien and Reniers-Decoen (*8*) showed that regeneration could proceed after the destruction of the interstitial cells by x-radiation. The same authors, by means of vital staining and grafting experiments, observed that an individual cell is labile, and found that it goes through several histological changes during its life cycle. In 1958 Zwilling (*9*) reported that total reconstitution of *Cordylophora* can be obtained from the ectoderm.

This is a preliminary report on experiments to show that total regeneration or reconstitution, or both, of hydra can develop from the endoderm alone.

The animals, *Pelmatohydra oligactis*, were collected and then cultured under simulated natural conditions. The procedure consisted first of the removal of the anterior end of the animal; then the remainder of the animal was treated with a buffered mixture of saturated solutions of pancreatin and amylase at room temperature, to digest the mesogleal layer. When the mesoglea was sufficiently digested, the two cellular layers of the animal were mechanically separated. The isolated endoderm and ectoderm were cultured separately in a saturated solution of sulfadiazine in filtered "pond" water at approximately 15° to 20°C. Within a few hours the endoderm formed a smooth-surfaced solid ball. Under optimum conditions, between 18 and 24 hours later, the ball formed an elongated hollow mass. At the end of 2 days of culture the elongated mass developed the ability to contract both longitudinally and circumferentially when gently stimulated mechanically. By the end of 3 days at least one tentacular nub could be seen. Between days 5 and 6 three short tentacles, complete with batteries of nematocysts, formed around a definable hypostomial region. The tentacles had the ability to elongate and contract. On the 7th day microcrustacea were introduced into the culture medium as food. The capture and utilization of food by the newly reconstituted animals were used as the criteria of their complete reconstitution.

In no case did the separated ectodermal layer reconstitute, although the cells often remained together for a few hours. Then they would either separate and disintegrate, or the whole mass would flatten on the bottom of the culture dish and disintegrate.

Stained preparations of the separated ectodermal and endodermal cell masses have shown that no histologically recognizable interstitial cells were included with the endoderm in these regeneration experiments. However, interstitial cells and all stages of their development into nematocysts were recognized in the ectodermal preparations.

Work is presently in progress to refine the procedures used to obtain the endoderm and to describe cytologically the events that take place during the reconstitution or regeneration of hydra from the endodermal layer.

DIANE K. NORMANDIN
Department of Zoology, University of Illinois, Urbana

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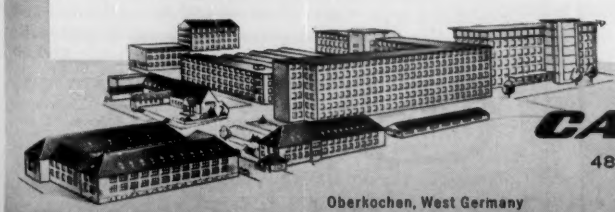

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6–10. American Assoc. of Textile Chemists and Colorists, natl. conf., Philadelphia, Pa. (G. P. Paine, AATCC, P.O. Box 28, Lowell, Mass.)

8. Helminthological Soc. of Washington, 50th, College Park, Md. (Publicity Committee, HSW, Animal Disease and Parasite Research Branch, ARS, U.S. Department of Agriculture, Beltsville, Md.)

9–13. Electrochemical Soc., Houston, Tex. (Electrochemical Soc., 216 W. 102 St., New York 25)

9–14. American Acad. of Ophthalmology and Otolaryngology, Chicago, Ill. (W. L. Benedict, 15 Second St., S.W., Rochester, Minn.)

10–12. Human Factors and Bioastronautics, conf., Dayton, Ohio. (J. J. Harford, American Rocket Soc., 500 Fifth Ave., New York 36)

10–12. Industrial Health, cong., Charlotte, N.C. (Council on Occupational Health, AMA, 535 N. Dearborn St., Chicago 10, Ill.)

10–12. National Electronics, conf., Chicago, Ill. (T. F. Jones, Jr., School of EE, Purdue Univ., Lafayette, Ind.)

10–12. Operations Research Soc. of America, natl., Detroit, Mich. (H. J. Miser, ORSA, Research Triangle Inst., 505 W. Chapel Hill St., Durham, N.C.)

10–14. American College of Surgeons, San Francisco, Calif. (W. E. Adams, 40 E. Erie St., Chicago 11, Ill.)

10–14. American Soc. of Civil Engineers, Boston, Mass. (W. H. Wisely, ASCE, 33 W. 39 St., New York 18)

11–13. Applications of Nuclear Energy, conf., Karlsruhe, Germany. (Ing. Küpfmüller, Deutsches Atomforum, Friedrichstr. 2 III, Düsseldorf, Germany)

11–13. Synthetic Rubber, 2nd intern. symp., London, England. (Rubber and Plastics Age, Gaywood House, Great Peter St., London, S.W.1)

11–14. Audio Engineering Soc., 12th annual conv., New York, N.Y. (H. F. Olson, RCA Laboratories, Princeton, N.J.)

11–14. Inelastic Scattering of Neutrons in Solids and Liquids, symp., Vienna, Austria. (International Atomic Energy Agency, 11 Kärntner Ring, Vienna 1)

12–13. American Vacuum Soc., 7th natl. symp., Cleveland, Ohio. (AVS, Box 1281, Boston 9, Mass.)

12–14. Astronautics, 3rd annual symp., Los Angeles, Calif. (Maj. G. Colchagoff, Propulsion Div., Air Force Office of Scientific Research, Washington 25)

12–14. Gaseous Electronics, 13th annual conf., Monterey, Calif. (N. L. Oleson, U.S. Naval Postgraduate School, Monterey)

12–14. Nuclear Reactor Chemistry, conf., Gatlinburg, Tenn. (C. D. Susano, Oak Ridge National Lab., P.O. Box Y, Oak Ridge, Tenn.)

13–15. Academy of Psychosomatic Medicine, Philadelphia, Pa. (B. B. Moss, 55 E. Washington, Chicago 2, Ill.)

13–14. Engineering Writing and Speech, natl. symp., Chicago, Ill. (M. Whitmer, Admiral Corp., 3800 W. Cortland St., Chicago 47)

13–15. Optical Soc. of America, Boston, Mass. (M. E. Warga, OSA, 1155 16 St., N.W., Washington 6)

14–15. Society of Photographic Scientists and Engineers, symp., Washington, D.C. (F. M. Brown, Photomechanisms, Inc., Box 67, Huntington Station, N.Y.)

15. American Soc. of Safety Engineers, annual, Chicago, Ill. (A. C. Blackman, ASSE, 5 N. Wabash Ave., Chicago 2)

15–16. American Acad. of Psychotherapists, 5th annual conf., Cleveland, Ohio. (B. J. Barkley, 1856 Coventry Rd., Cleveland Heights 18, Ohio)

16. American College of Dentists, Los Angeles, Calif. (O. W. Brandhorst, 4236 Lindell Blvd., St. Louis 8, Mo.)

16–22. High-Speed Photography, 5th intern. cong., Washington, D.C. (V. H. Allen, Soc. of Motion Picture and Television Engineers, 55 W. 42 St., New York 36)

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17–19. American Oil Chemists' Soc., fall, New York, N.Y. (W. C. Ault, U.S. Dept. of Agriculture, Philadelphia 18, Pa.)

17–20. American Acad. of Pediatrics, Chicago, Ill. (E. H. Christopherson, 1801 Hinman Ave., Evanston, Ill.)

17–20. American Dental Assoc., Los Angeles, Calif. (H. Hillenbrand, ADA, 222 E. Superior St., Chicago, Ill.)

17–21. Neutron Pile Research, symp., Vienna, Austria. (International Atomic Energy Agency, 11 Kärntner Ring, Vienna 1)

17–22. Diagnosis and Treatment of Acute Radiation Injury, Geneva, Switzerland. (World Health Organization, Palais de Nations, Geneva)

17–26. Plastics Processing, intern. cong. and exhibition, Amsterdam and Utrecht, Netherlands. (Secretariat, c/o N. V. 't Raedthuys, Tesselschadestraat 5, Amsterdam-W, Netherlands)

18. Oak Ridge Inst. of Nuclear Studies, Oak Ridge, Tenn. (W. G. Pollard, Box 117, Oak Ridge)

18–20. Mathematical Optimization Techniques, symp., Berkeley, Calif. (R. M. Oliver, Dept. of Industrial Engineering, Univ. of California, Berkeley 4)

18–21. American Dietetic Assoc., 43rd annual, Cleveland, Ohio. (M. L. Ross, Simmons College, The Fenway, Boston 15, Mass.)

19–20. American Geophysical Union, Moscow, Idaho. (A. N. Sayre, U.S. Geological Survey, Washington 25, D.C.)

19–21. Design of Experiments, 6th conf. (by invitation only), Aberdeen Proving Ground, Md. (F. G. Dressel, Office of Ordnance Research, Box CM, Duke Station, Durham, N.C.)

19–21. Space Navigation, symp., Columbus, Ohio. (Institute of Radio Engineers, 1 E. 79 St., New York 21)

19–26. Measuring Techniques and Automation, 2nd intern. cong., Düsseldorf, Germany. (Nordwestdeutsche Ausstellungs-Gesellschaft, Ehrenhof 4, Düsseldorf)

20–21. Hypervelocity, symp., Denver, Colo. (R. R. Dexter, IAS, 2 E. 64 St., New York 21)

20–22. Acoustical Soc. of America, San Francisco, Calif. (V. Salmon, Stanford Research Inst., Menlo Park, Calif.)

20–22. Institute of Management Sciences, 7th intern., New York, N.Y. (J. Townsend, IMS, 30 E. 42 St., New York 17)

21–22. Association of Midwestern College Biology Teachers, 4th annual, Mankato, Minn. (L. Zell, Mankato State College, Mankato, Minn.)

21–22. Research Approaches to Psychiatric Problems, symp., Galesburg, Ill. (T. T. Tourlentes, Galesburg State Research Hospital, Galesburg)

21–25. American Heart Assoc., annual, St. Louis, Mo. (AHA, 44 E. 23 St., New York 10)

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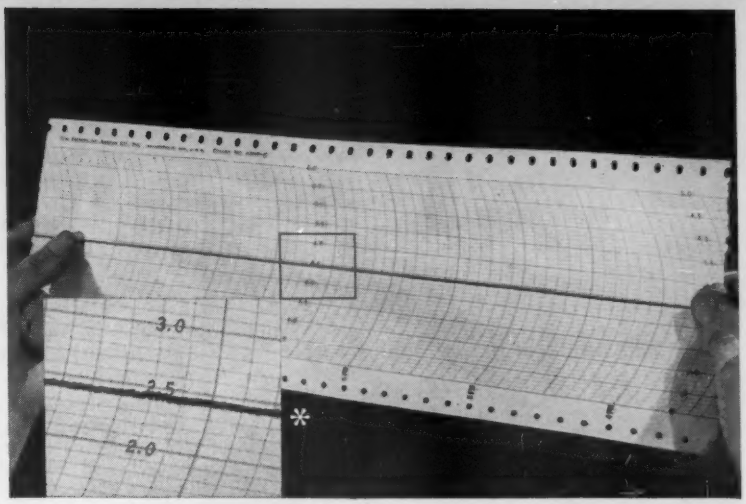
JOSHUA STERN

National Bureau of Standards, Washington, D.C.



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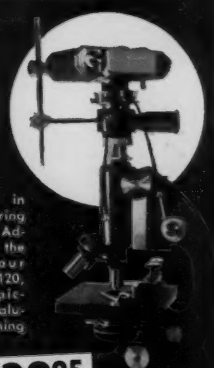

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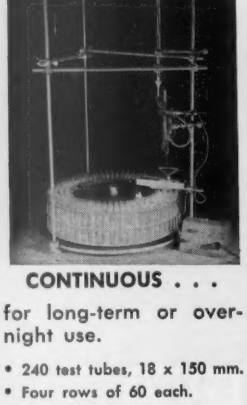

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Letters

On Un-American Science Reporting

The views expressed by your contributors are, of course, their own, and hence, in a given reader's opinion, may be biased or inaccurate or both. This is the essence of free speech. But one has the right, I believe, to expect factual material to be reported truthfully and objectively, without sneers and without slanting. Such is not the case in the news article published in the 1 July issue [*Science* **132**, 24 (1960)] entitled "Un-American Science." The facts as stated are false and misleading. Richard Arens, staff director of the House Committee on Un-American Activities, is reported as having "enemies" who seem to be making progress in getting his job. The reason for this happy situation, as your reporter sees it, is that Arens has been helping W. P. Draper, a New York millionaire, make certain grants, the purpose of which is to prove the Negro mentally inferior to the white, and eventually to work out a plan to send American Negroes back to Africa. Your reporter asserts with poorly concealed glee, that although Representative Walter is, for some reason, not greatly excited, Speaker Rayburn "appeared" to be "extremely upset" by Arens' activities in behalf of "un-American science" and that "it is believed that Arens will no longer be staff director when the next Congress convenes."

Now this stuff is a queer mixture of truth and falsehood. It is true that Arens has enemies, as has every patriotic American who comes out publicly and courageously against subversion, even when found in high places. It is also true that Representative Walter is not concerned about Arens' connection with Draper. It is false that Speaker Rayburn is greatly "upset"; and unfortunately for your reporter's peace of mind, it appears as though Arens will continue as staff director of the Un-American Activities Committee for some time to come.

Your reporter's story is even more reprehensible in its references to W. P. Draper. Draper *is* interested in racial differences, and he would like to see our present immigration laws remain on the books. He is not interested in "proving" the Negro mentally inferior to the white, and he has never proposed a plan for sending Negroes back to Africa nor does he advocate such a scheme.

Draper has made several grants for research in the general area of race relations. His reasons are twofold. First, he believes that objective, unbiased work on racial matters is impossible in those university departments where the equalitarian dogma has been accepted as a basic premise. And secondly, he believes that young men of independent mind hesitate to publish results showing racial differences for fear of reprisal from the almost fanatic believers in racial equality. To those who have experienced the vaunted "tolerance" of the dedicated "liberal," neither of these propositions will seem to be extreme. Grants for research have been made and work is in progress. In no case have any strings been tied to these grants with respect either to method or results. I know this to be true, as I have placed several grants myself.

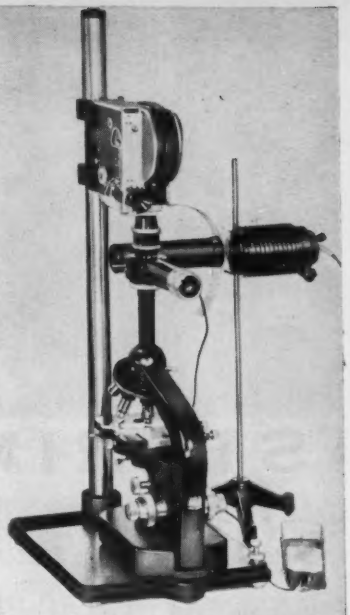
Apparently, your reporter took the "facts" for his story from a news item published some months ago in a Midwestern newspaper by a feature writer who wanted to discredit the Un-American Activities Committee. No attempt, obviously, was made to check the accuracy of these scurrilous statements. As a result, his article is a snide affair in which the editors of *Science* can take little satisfaction.

HENRY E. GARRETT
1872 Winston Road,
Charlottesville, Virginia

Education and Research

It seems to me that Sander Rubin [*Science* **132**, 46 (1 July 1960)] has inadvertently put his finger on the crux of the problem with his statement: "The primary mission of a college is to educate its students, not to conduct research." This is a distinction that is all too frequently made and one that is, in my opinion, false. Certainly in the physical sciences (the only area in which I can claim special competence) one of the things that every student should learn is that the sciences are not a static thing to be learned once and for all, but a continuously growing thing in which new developments require periodic major overhauls of our ways of looking at, and understanding, the universe around us. One of the most important things that a young person can learn in school is the necessity of keeping up with his field, and probably the most important things that such a young person can learn in school are the methods of study and the habit of study which make it possible for him to do so. These are things that, I think, can be really learned only in an atmosphere in which some research is actually going on.

Although I can personally certify to the necessity of these lessons only in the physical sciences, I strongly suspect that it would do no harm for the liberal arts majors to learn them too, at least in the areas of economics and po-



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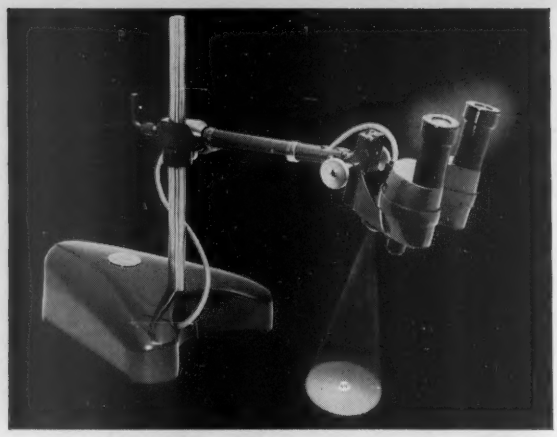

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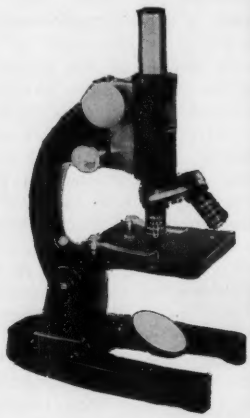

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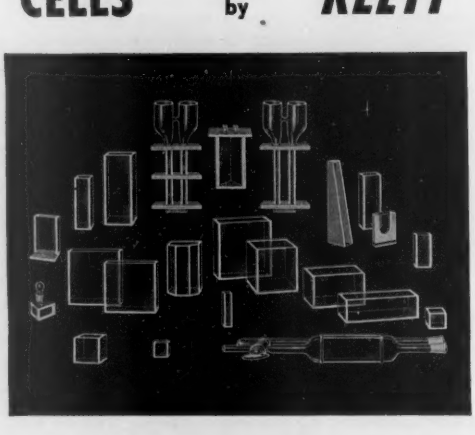

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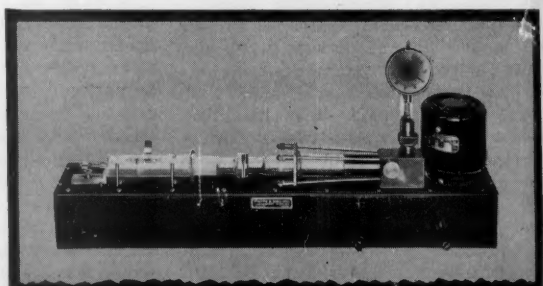

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litical science. It has become almost a platitude that the physical sciences have progressed, in recent years, at a rate astronomically greater than the rate of progress shown by the economic and political sciences. I believe one reason for this may be that the nonphysical sciences are too often taught as immutable truths, not subject to continuous re-examination and re-evaluation as a result of experimental tests—that is, research.

CHARLES F. ROBINSON
Consolidated Electrodynamics Corporation, Pasadena, California

May I comment on the statement of Sander Rubin about my "position" in the matter of teaching and research? He stated only half of it—and half a position is worse than none—when he noted that I claimed "any scholar not doing research simply cannot be a fully effective teacher." I also claimed—and neither half is complete in itself—that any scholar not immersed in teaching may have great difficulty in being a fully effective research worker. The point of my letter was not to take sides or to state an ideal but to propose that side-taking in this issue is tantamount to missing the point.

Some scholars prefer teaching, others research; some cannot make a sensible dichotomy. Whatever the case, to prefer one to the *exclusion* of the other may turn one aspect of scholarly activity into a mere technical competence like watchmaking or ghostwriting.

The deeper question is whether we want our universities and colleges (unlike our secondary and preparatory schools) manned by scholars or by Mr. Chipses. The original editorial and my letter [*Science* **131**, 71, 1282 (1960)] came down firmly on the side of scholars. The ultimate question may be whether a university should "give" an education by "good teaching" or create the kind of place in which an education is available to those who have sufficient interest and intelligence to take it.

PAUL BOHANNAN
Northwestern University, Evanston, Illinois

Shatter Cones and Their Origin

The shatter cones in fine-grained limestones and dolomites, described by Dietz [*Science* **131**, 1781 (1960)] are merely a much-magnified version of the cones of percussion well known to archeologists. It is this conical or conchoidal fracture in flints and cherts that made flint-working possible and started mankind on the technological exploitation of his environment.

Miniature cones of this kind are perhaps best seen in plate-glass doors and windows, where they have been produced by the impact of pebbles thrown up by passing cars, or bullets from air rifles or .22's in the hands of teen-agers. The apical angles of these cones are much blunter than in those shown by Dietz—well over 90° in all I have seen. This is presumably because of the lower impact velocity or lower energy of the pebbles, relative to that of a meteorite.

Cones of this perfection rarely if ever appear in worked flint, probably because man had no use for them. The impact of his hammerstone or flaking punch was deliberately localized near the edge of the flint block, so that a flake of controlled size and shape could be split off.

Surely somebody must have worked out the mathematical theory of shock waves in extended solids, such as a thick stratum of stone. Empirically, it can be seen that a greater impact produces sharper cones, that the conical wave penetrates deeper before being damped, and that at high velocities and energies the irregularities in the medium become a less controlling factor. Dietz speaks of shatter cones which have penetrated more than 12 meters in shale, a laminated stone, whereas impact cones are usually stopped by the layer of plastic in safety glass. Nevertheless, the phenomenon of conical fracture in stone cannot be considered one of great energies or velocities, except in so far as the size of the cone is concerned.

I do not recall having seen parasitic coning in flake surfaces in chipped flint. However, this is perhaps because of the distortion of the conical wave form and the different order of magnitude of the energies produced by a blow of a hammerstone and the impact of a meteorite.

The apex of the cone is ordinarily at the point of impact, and this cannot be the case with the parasitic cones. I presume that they develop where the main shock wave strikes some structural discontinuity in the stone, which initiates a new wave at that point. This suggests that where the apices of the presumed master cones are found below the surface of the rock strata, they may themselves be parasitic to a much larger cone with its apex at the surface, produced by the impact. Perhaps more logically, they may have been initiated at points along the front of some sort of spherical shock wave, if such forms exist.

I question Dietz' conclusion that volcanic explosions cannot initiate shatter cones, though they may not be able to produce cones as large or as sharp as those in his illustrations. In any case, cones of volcanic origin should be produced with their apices pointed

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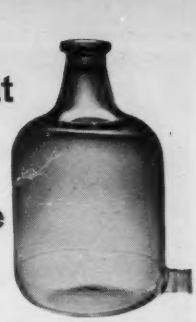

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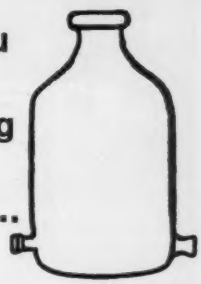

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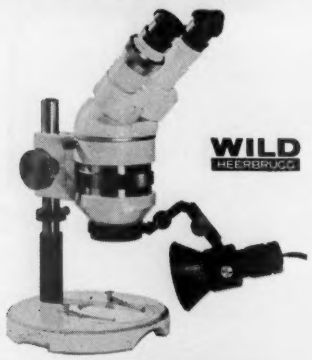

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downward, or at least toward the focus of volcanic shock, and not toward the surface. Dietz does not specify whether this was the case with the cones at the site of the underground nuclear bomb test.

P. SCHUYLER MILLER
Allegheny Chapter, Society for Pennsylvania Archaeology, Pittsburgh

Formation of cones is a well-known common mode of failure both by percussion and by static loading. The point I make is that shatter cones are a *distinctive* type of percussion cone apparently related in nature to hypervelocity meteorite impact and a subsequent engulfment of the rock by an intense shock wave.

Conchoidal coning is *another* distinctive mode of coning. It is typical of glassy and isotropic cryptocrystalline solids. As the name implies, it is characterized by horizontal shell-like ribbing. Prehistoric man, and convicts working on the stone piles at Sing Sing for that matter, have produced uncounted millions of conchoidal fractures but never a shatter cone.

As I mentioned, artificial shatter cones are produced by nuclear detonations and high-*brisance* explosives. Just recently I have received from E. M. Shoemaker and D. Gault a plaster cast of the target crater produced in Kaibab limestone by a 3/16-in. glass pellet fired at 18,000 ft/sec at the Moffet Field laboratory of the National Aeronautics and Space Administration. At ground zero there is a beautiful nest of minute shatter cones.

The apex of a shatter cone is not the point of impact; rather, shatter cones are formed by the spherically spreading shock wave when it strikes some lithologic discontinuity. The spreading of the fracture is then limited by the next lithologic discontinuity, so that the cone may be either 1 centimeter long or many meters. The apex of the cone points toward the advancing shock-wave front. At the nuclear detonation site mentioned, jumbled and caved rocks had fallen into the explosion cavity. It was not possible to reconstruct the original orientation of the shatter-coned rock.

Shatter cones have never been reported from volcanic explosion sites. I don't believe they exist. Discovery there would be a simple and sufficient disproof of my thesis that shatter cones are a distinctive criterion for hypervelocity meteorite impact. I urge volcanologists to search for them. Science progresses not only by the discovery of new truths but also by discarding erroneous hypotheses.

ROBERT S. DIETZ
U.S. Navy Electronics Laboratory, San Diego, California

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